ENGINEERING

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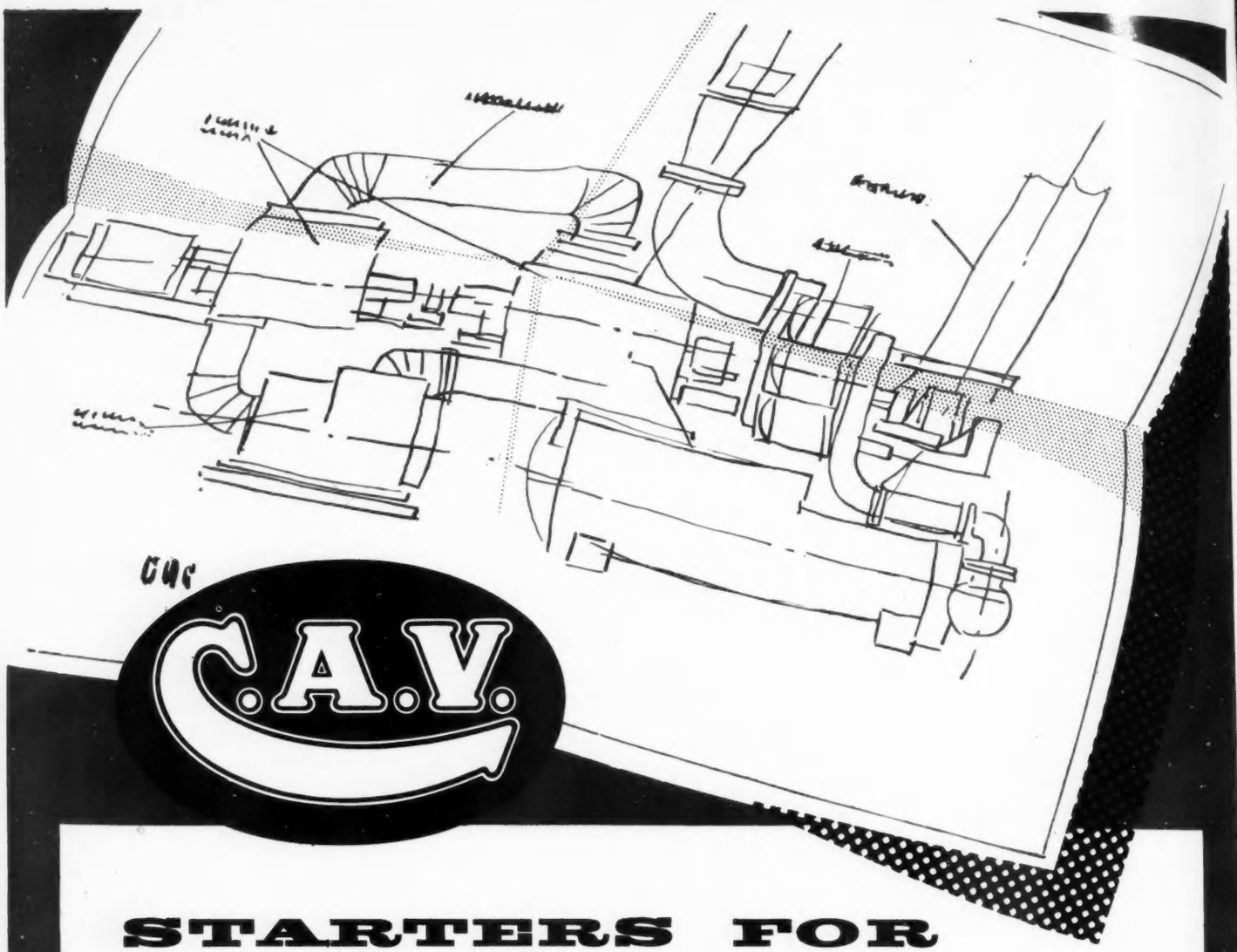

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Power Politics

AFTER the war, we had to have power and we had to have it quickly. Coal, it appeared, was likely to be scarce and costly in only a few years. Nuclear energy was the promising alternative. An organisation, originally conceived for military purposes, eventually became the United Kingdom Atomic Energy Authority with terms of reference extended to cover research and development for a civilian programme. So great has been the pace and urgency with which the programme has been pursued, that it has proved necessary to continue detailed studies of components for a nuclear power station when its construction is already under way. Scarcely are the foundations of one station in position than designs are ready for another—so much an improvement on the first that for little extra capital cost the power output is almost doubled. Nuclear power station projects are so vast that it has been necessary to form agglomerative industrial organisations to cope with them. On top of this, the Central Electricity Authority has been reconstituted, presumably to meet the new situation, with part of its function taken over by the Central Electricity Generating Board. All these measures and developments have been largely *ad hoc*.

Cracks in the fabric are already beginning to show. It has recently been revealed that the exponential demand curve on which estimates of future electricity requirements have been based no longer illustrates the facts. Though it is easy to be wise after the event, an exponential demand curve must eventually lead to an impossible situation; sooner of later it is bound to predict a demand that is inconceivably large. There also seems to have been a dangerous tendency to extrapolate, and to compare the development of nuclear reactors with other power plant, developing at times and in situations different from our own.

Unexpected developments have included the apparently unforeseen current glut of coal, and the vast increase in stocks of uranium; as much as 30,000 tons a year are now available to the West. This abundance of fissile fuel led Sir John Cockcroft last week to point out that the development of the fast reactor was no longer as urgent as it once had been. In a rapidly growing industry like atomic energy, such unpredicted changes in the situation are unavoidable and allowance for the fortuitous has generally been made; the U.K.A.E.A. have promoted remarkably few expensive failures, if any, and been quick to cut their losses on reactor systems that have seemed less promising. The electricity boards and the Central Electricity Authority have also acted in the national interest within their terms of reference. But the overall planning of energy development seems to have been less sagacious.

Recently Mr. A. L. G. Lindley, general manager of the G.E.C. Atomic Energy Division, said it would be possible to build nuclear power stations of 800 MW capacity at little higher cost than stations of 300 MW now under construction; to the manufacturers of plant this might yield diminishing returns. In addition, the United Kingdom atomic power programme, of 6,000 MW by 1965, had been cut, possibly though not definitely, by 10 per cent. Finally, the sale of plants abroad was likely, initially at least, to be limited to countries with power problems similar to our own; such potential customers would in general be industrial countries capable of building and installing much of the necessary plant themselves. Exports might therefore be mainly restricted to technical know-how. For these three reasons it might be difficult to recover the very considerable sums that had been expended by the atomic power groups on research and development.

What seems to be more serious is that the groups should have been led into a position where they have cause for anxiety. They have in good faith met the new and desperate demands made on their resources, and with the assistance of the Atomic Energy Authority made Britain safe from power shortages. Their participation has been sought in artificial circumstances which exclude the normal planning of commercial enterprise. They have not apparently had access to all the information necessary in formulating policy. They have evidently not even been advised of the exact extent to which the original nuclear programme is to be cut.

Clearly, it is not only the Atomic Energy Authority that needs to be re-examined in the light of the Fleck report; the same rethinking might be extended to the whole national power policy. Terms of reference need to be defined and made explicit, lines of communication checked for faults. Possibly the civilian side of the U.K.A.E.A. should be severed from its military Siamese twin so as not to be ham-strung by security. All the various organs of the power industry can only act in harmony if information is exchanged freely, and if national policy is rationally formulated and unequivocally stated.

Otherwise the house is built on sand.

Cover Picture.—*A reboiler is used to heat liquid hydrocarbons until they vaporise. In the unit illustrated, the 1,600 ends of 800 "hairpin" tubes, ¾ in in diameter, are being welded into the 5 in thick tube-plate, 5 ft 5 in in diameter. The working pressure in the tubes is 280 lb per sq. in.*

* * *

Plain Words

Of all the boxes that man chooses to travel in, I rank the modern lift highest in modest efficiency. Its smooth interior and simple row of push-buttons give no hint of the complex equipment that shunts it from floor to floor. Its silent travel removes all sense of movement, except when slowing down at the requested floor. It has no uniformed attendant.

The development of lifts has been a complex process, depending on the steady evolution of equipment and the less steady convolutions of public taste. Early lifts were impressive to see and ride in. The finest examples were ornamented cages of ingenious decoration; a liveried servant manipulated a counterbalanced rope, foot by foot; and every foot of travel was a creaking triumph.

Now tastes have changed. The lift is part of a large block of offices. It has to be impersonal and efficient. Yet a lift is only a disappointed train. Why have lift contractors outstripped the railway designers in the development of automatic control? The railway considered as a system is much more complicated, but it has already a comprehensive signalling and communication system. The means for automatic control are there. Use should be made of them.

The London Underground would be a good starting point. Already programmed signalling devices are replacing signal cabins on the Northern Line. The same sort of equipment should be further developed to remove the driver's cabin from the trains. All that the driver has to do at present is start and stop the train in accordance with the automatic signals presented to him. The same operations can be carried out by automatic equipment in the train; just as similar functions are performed by the automatic equipment controlling lifts. Train driving is an exacting task, not because it is complicated but because the driver has to be alert all the time, watching for signals. Automatic equipment in the train could carry out the same task with ease. Valuable men would then be released to take over jobs more suited to their abilities.

There was no public outcry when automatic lifts were introduced; there should be none on the introduction of automatic trains. In addition, some platform staff could be removed. The manipulation of the doors by automatic equipment can easily be preceded by the automatic broadcast of a "mind-the-doors" signal over a loudspeaker system. Of course, platform staff shout other messages too: I've never managed to understand them, but I am reliably informed that most of it could be committed to record and rebroadcast at the appropriate moment. The present practice should be relegated to a museum, as an appendix to "Street Cries of Old London."

Railways have long been romantic things but they must move with the times. London Transport are developing electronic bus control, and programme signalling on the tube. They could well give the lead in completely automatic train control.

CAPRICORN

Weekly Survey

Wage Costs and Capital Costs

A fresh angle on an old problem has been raised by Sir Robert Shone and Mr. H. R. Fisher in a paper called "Industrial Production and Steel Consumption," given to the Royal Statistical Society. In this paper the authors were concerned among other matters to augment the rate of increase in productivity. They foresee, as others have done, that this is not necessarily going to be achieved by merely increasing industrial production.

The authors of the paper are conscious of the need to stimulate an increase in production in the right industries thereby keeping export prices down and defending the balance of payments position. They propose therefore that consumption might be directly curtailed in order to release resources for investment and export. To this end they would favour increases in superannuation contributions by employed persons. This would effect a reduction in the purchasing power of consumers. They also suggest that productivity could be stimulated if labour costs were allowed to rise relative to capital costs. This could be done by raising employers' contributions to the welfare state. They finally put forward the view that labour costs are artificially depressed compared with capital costs because the price structure of the nationalised industries favours domestic consumers who thereby get their fuel subsidised. If, for example, the prices of fuel were raised to the general consumer as opposed to the industrial user, this would tend to cause a demand for higher wages to meet the rising cost of living which, if granted, would raise labour costs and therefore make it more attractive to invest in capital equipment thereby increasing productivity.

A short-term economic policy based on this type of thinking would depend for its success on timing and on being adopted in its entirety. The authors think that the present time would be a good one to carry it out because raw material prices are falling but even if the times are temporarily propitious, it could be exceedingly hazardous to stimulate an increase in wage costs unless some form of taxation (the authors suggest increasing N.H.S. and superannuation charges) were imposed at the same time. It would rely for its success on almost split second timing by the machinery of government. The price of failure would be serious inflation.

Scotland and Technological Change

While the Chancellor of the Exchequer was busy last week taking final advice on the reduction in Bank Rate from 7 to 6 per cent (the change took place on Thursday, 20 March), his colleague the Minister of Labour has been completing a tour of some of the more industrially depressed parts of Scotland. The unemployment rate in Scotland is now about 3·6 per cent compared with a national average of about 1·9 per cent, and in Dundee the average is 5 per cent and at Greenock it is 8 per cent—the only worse spot at the moment being Northern Ireland at 9 per cent. Scotland was a Special Area before the war and has been a Development Area since. At the moment serious unemployment is only encountered in the Dundee and Greenock sections of Scotland's industrial belt but the country as a whole is clearly apprehensive about its continuing dependence on heavy capital goods industries, and memories of the great depression die hard in those parts.

Dundee's troubles are due partly to the high price of raw jute and partly to the long-standing technical conservatism of the jute industry. Greenock has suffered unemployment because the docks are at long last increasing their efficiency by reducing labour; because the ship repairing facilities are limited; and because of the defence cuts which have reduced employment at the ordnance factory at nearby Bishopton and the closing of the torpedo experimental establishment at Greenock itself. These are all local difficulties. Scotland's coal, steel and shipbuilding and engineering industries are still doing well although order books have been shrinking. These areas are thus mainly the victims of slow adaptation to technical change.

Conservatism in technical matters with certain important exceptions, has been a national characteristic of the Scots for many generations. It was apparent even in the 1930's that the depression was worsened by a certain degree of technical backwardness. To-day many of the new light industries which have come to Scotland are owned by American companies, employing Scottish labour but American techniques. In the adoption of modern industrial techniques, both managerial and technical, the Scots often give the impression of lagging behind the English who themselves often enough compare badly with the Americans and Continental Europeans

Steady Ahead

The installation of anti-roll Denny-Brown stabilisers in the Cunard Liner Queen Mary has now been finished. Her equipment in this respect will now be similar to that in the Queen Elizabeth. The installation of the equipment has been a difficult technical problem owing to the layout of the ship's machinery compartments. In the end the internal parts of the stabilisers have been arranged so that the hydraulic rams operate vertically instead of horizontally.

One of the interesting aspects of fitting the ship in this way is economic. It is thought that the cost of the stabilisers and their installation has been at least £½ million and that about £¼ million has been spent on this year's annual overhaul. Altogether this represents a very substantial investment in a ship which is already 22 years old. It suggests that she is expected to have a useful life on the North Atlantic run with her sister ship well into the 1960s. This might well be a critical decade for marine engineering. The economics of air versus sea transport will have progressed into the gas-turbine era on the North Atlantic air route and some better idea will be available than now of the prospect of using atomic energy for the propulsion of commercial shipping. It looks as though it will be a long time before ship-breaking yards take delivery of the Queen Mary.

An Ill Wind

The recent low level of sea freights which is causing so many ships to be laid up and may in due course have an adverse effect on the order books of the shipyards, has resulted in a fall of about 20 per cent in the cost of importing iron ore into the United Kingdom. This has brought down the price of foreign ore c.i.f. United Kingdom port by about 15*s*. a ton compared with last year. A small cut in steel prices is now being talked of, though this would probably be less than the 7½ per cent rise which took place in July, 1957. Even so, it would be welcomed by the engineering industry in particular as well as by all those who hope to see a brake put on inflation.

Britain's competitive advantages arising from lower steel prices compared with Continental countries have been the subject of two studies by Mr. Edward Sara of the United Steel Companies. The most recent one, published last November confirmed the conclusion of the

earlier one that Britain's price advantage was firmly based. Greater "realism" in coal and scrap pricing would not, in his view, raise the price of steel by more than £1 a ton. In any case, much British coal is now sold for more at home than it will fetch abroad though the reverse was certainly the case when his first study was published in 1953 and may still have been last November. The recent fall in c.i.f. prices of iron ore will probably benefit Britain more than, say, Germany which is more dependent on home produced ores and minette ores from Lorraine. In so far as the lower British steel prices are due to prohibition of scrap exports and restriction of steel exports, the British Iron and Steel Federation takes the view that if the Free Trade Area came into being and the restrictions had to be lifted it would result in an increase in British steel prices.

Another important factor affecting prices is, of course, the future trend of steel consumption which has been the subject of the two "Development Reports" of the Iron and Steel Board. So far, while their estimates have not been widely out, they have not inspired complete confidence in their sales forecasting. In particular, the future seems likely to see a decline in British exports of goods with a high steel content and low labour content relative to those with a high labour content. The numerous steelworks constantly being erected overseas are soon going to add strip mills and wire drawing plants and later perhaps will make, say, railway wheels and axles.

World Bank and Sterling Area

Since the war the United Kingdom has, in spite of difficulties, remained the "predominant source" of capital for the sterling area. Exports of long-term capital from Britain have been at the rate of £150 million a year, that is for nearly three-quarters of the capital imports of the sterling countries. This outflow of capital has been supplemented by loans from the World Bank, which, according to an article by Mr. W. A. B. Iliff in the *National Provincial Bank Review*, have now reached a total of £420 million, representing about one-third of all the loans made by the Bank. Loans in the past six months alone come to £65 million.

The largest of all the Bank's borrowers is India with a total loan of £133 million. Next come Australia, with £114 million, South Africa, with £57 million, and Pakistan, with £40 million. Burma, Ceylon, Central Africa, East Africa, Iraq and Iceland have all had smaller amounts. The Bank's loans have a life of from 5 to 25 years with half-yearly amortisation payments, and charges geared to those of the New York market. Interest rates vary from 4 per cent on earlier loans to $5\frac{5}{8}$ per cent on the more recent ones.

Apart from Britain and the Bank, the Sterling Area countries have received additional sums from the United States and in smaller amounts from Canada, Germany and Switzerland. One important point about the Bank's loans is that as they have been made in dollars, interest and service charges have also been in dollars and have cost between 25 million and 30 million dols. a year. Even so, the completed projects will pay off in terms of increased economic strength. Two-thirds of the Bank's lending has been for roads, railways, power and other basic services. And these are the investments which have in the past unlocked the door to the rich unused resources of the world.

New Inspiration for the F.T.A.?

The next meeting of the Ministerial Committee on the Free Trade Area takes place on 31 March. It will be surprising if much progress is made. It is apparent that a deep cleavage could develop now within the negotiations for this free trade zone for French hostility to the Free Trade Area idea continues unrelenting. Its proposals which have been put forward as a counter-stroke to the British draft have pleased no one. The other five members of the European Economic Community (which make up the European Common Market) disapprove of them almost as much as the more influential members of the 11 countries outside the European Economic Community who might join it to make up the Free Trade Area. The prospect of deadlock is probably not unpleasing to the French who are convinced that the implementation of the Treaty of Rome, which sets up the European Economic Community, is as much as they can take on for the time being. The Italian Government has suggested a compromise arrangement between the British and French points of view on the problem of tariff disarmament and this is reported to have aroused a certain amount of interest in London. There may be a compromise possible on this basis, but only the optimists think that this is likely.

The fact is that a fundamental difference of attitude, more political than economic, is gradually being forced on the surface. The French particularly see the economic integration of western Europe as a stepping stone to fairly rapid political integration in which a federal system is evolved within a high tariff community. This would then become a rich and powerful political entity holding the balance between the Russians and the Americans. It is the "third force" brought up to date and it is the basic urge which is impelling the Latin members of the European Economic Community in particular in their drive towards unity. It is a far cry from Britain's free trade crusade for western Europe, continuing economic and political co-operation with the Commonwealth and emotional attraction to the North Atlantic Treaty. At the moment the initiative is with the Common Market idea and all that lies behind it. The Free Trade Area idea badly needs a corresponding, vitalising, basic political conception.

Dimensions and Inspection

The Engineering Metrology Association was born out of a series of lectures given at the Northampton College of Advanced Technology in London towards the close of 1950. The first ordinary meeting was held in February, 1951, and this has been followed by monthly meetings in the spring, autumn and winter of each year. The original association was called the Association of Metrologists but it was given its present title in September, 1951, since, although metrology includes all aspects of length, mass and time with the derivatives volume, density, force and pressure, most of the members are usually interested mainly in dimensional metrology.

The association has now completed 50 ordinary meetings over a period of six years and in appreciation of the help given by Northampton College an annual donation to the college prize list was started in 1955 to give an award for the best student of the year whose studies included a metrological subject. Two such awards have already been made.

At the present time the membership stands at about 100 including small groups in the Birmingham and Manchester areas. At a meeting in 1957 the association held a formal debate as to whether current inspection methods are out of date or not. This is a subject which is increasingly attracting engineering attention. Not only the methods but the training and qualifications of inspectors are being challenged and this challenge impinges on the ground covered by metrology. The latest of these criticisms of the scope and quality of inspection has come from the Society of Licensed Aircraft Engineers (see ENGRG., 7 March '58, p. 291). As the age of automation develops it is bound to bring with it increased instrumentation and increased efforts to measure both more rapidly and more accurately by systems of remote control.

Letters to the Editor

ADVERTISING EXPORTS

SIR, It is good to see a prominent engineering journal running a leading article on advertising, particularly when the subject is handled in such a reasonable manner ("What Kind of Bird?", p. 353, of last week's issue).

The figures you quote for the export of engineering products sound good—but how much better they could be if more sales promotion effort, including advertising, was directed towards those overseas markets.

As an agency which specialises in handling advertising for industrial companies, we know how small a proportion of the average engineering firms advertising expenditure is usually directed abroad.

Even the use of the British technical Press as a means of attracting overseas business is not fully appreciated. About 37 per cent of your circulation goes abroad, and our records show that 30 to 35 per cent is about the figure for most good journals of the British technical Press. This is a fair indication of the world-standing of British journals, because one-third of the total of all circulations amounts to a large number of copies; moreover, they reach the very people who make up Britain's export figures.

Yet the total advertising expenditure in technical journals in 1957 was under £3,300,000, or just below 1 per cent of the £330,000,000 spent on all advertising in that year. That 1 per cent investment helps to bring a big return for the nation. How right you are to say that specialised products are not advertised enough!

Yours faithfully,
D. J. WOODROFF.

Doig Advertising Limited,
10-12 Great North Road,
Newcastle upon Tyne, 2.
21 March, 1958.

RAILWAY COACH VIBRATIONS

SIR, I am interested in Mr. A. F. Cook's letter, published on p. 259 of ENGINEERING for 28 February, and in his support for the suggestion of assessing the comfort of the riding of a coach on the mean acceleration alone.

The example in my paper was given to show the methods of working and it may be true that the error involved by considering only the mean acceleration in this case is not much; but may I quote two results based on lateral accelerations:

Coach	Mean acceleration, ft per sec²	Average frequency of events, c. per sec	Comfort riding factor, hours
Type A	1·59	1·6	4·7
Type B	1·55	0·85	6·3

The values of the mean acceleration do not indicate any marked difference between the rides, but, because coach type B has a much slower movement of greater amplitude than coach type A, the comfort riding factor is 34 per cent better. While agreeing with Mr. Cook that the comfort riding factor is approximately proportional to the inverse ratio of the equivalent acceleration (at 1·4 c/sec) I think the above examples show how different the equivalent acceleration can be because of the different frequencies involved: the importance of considering frequency is shown by graphs of $\frac{1}{\tau} - f$ curves, Figs. 7 and 8 of the paper.

The method where frequencies in a whole test are averaged is the one normally used to obtain the comfort riding factor, and then the time taken in arithmetic is only about three minutes more than that required for calculating the mean acceleration: the suggestion that it is very much simpler to assess the riding of a coach by its mean acceleration therefore seems

Continuing Letters to the Editor

to me to be more apparent than real, quite apart from the relative merits of the bases of assessment.

Yours faithfully,
J. C. LOACH,
Superintendent,
Vehicle and Track Division.

Research Department,
British Railways Division,
British Transport Commission,
55 Ashbourne Road,
Derby.
17 March, 1958.

Editor's Note: A summary of Mr. Loach's paper was given on p. 186 of ENGINEERING for 7 February, entitled "Passengers in Railway Coaches"; and a letter by Mr. Loach was published on p. 227 of our issue for 21 February.

SEALING BY O-RINGS

SIR, I wish to refer to the article "Pressure Sealing by O-Rings" which appeared on p. 314 of your issue of 7 March and, in particular, to Fig. 4. The arrangement as shown is likely to confuse your readers as the copper shrouds are omitted. The attached reproductions, Figs. 1 and 2, illustrate the pipe joint and joint ring correctly.

A further misunderstanding may arise from the description of the mechanism of the joint. The shrouds are so designed that when both sealing faces of the pipe ferrule abut against them, the volume of the space bounded by these faces and the inner and outer shroud is approximately equal to that of the rubber seal. It has been demonstrated that although rubber can be readily deformed, it is virtually incompressible. Thus, after deformation, to occupy the space allotted to it, any subsequent reduction of that space due to the copper shrouds compressing under load, gives rise to extreme interface pressures between the rubber and the sealing faces. This interface pressure being considerably higher than the fluid pressure a fluid-tight joint is achieved. It will be agreed that toroidal seals do not normally function in this manner.

There is a point about the arrangement shown in Fig. 3 (*b*) which may be of interest. A design similar to that shown was tested with external pressure and failed at 106 lb per sq. in. Admittedly, it was only a small size seal, but it provided a reasonable safety factor when under subnormal pressures.

Yours faithfully,
B. COOKE.

22 Wellburn Park,
Jesmond,
Newcastle upon Tyne.
12 March, 1958.

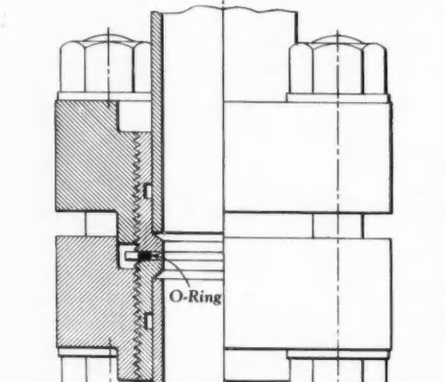

Fig. 1 Experimental pipe joint.

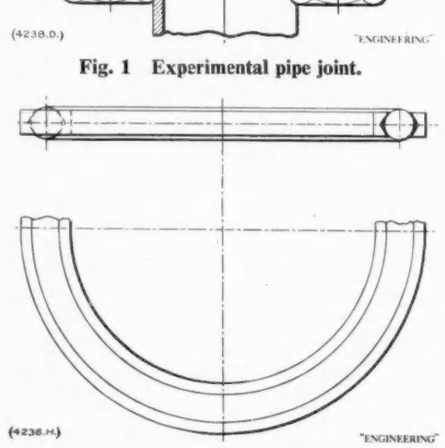

Fig. 2 Shrouded O-ring used in pipe joint.

SEA DEFENCE WORKS

SIR, I have found the correspondence concerning Hurst Spit very interesting, particularly the letter by Mr. W. J. Reid, published on p. 323 of your issue of 14 March, and with special reference to his last paragraph.

In most of the discussion about Hurst Spit, which has clearly been governed by the movement northwards and inshore for a distance of over 500 ft in some places during the last two centuries, a very great deal has been said about watching, and surveying, the visible manifestations of this shingle crest and the movements which occur.

It is not, in my opinion, sufficiently realised that the historical movements of unrevealed contours to "storm-windward" of an area of this sort, say down to the five fathom line, are the true indices of the leeward erosion of those basic clay shelves and crests upon which shingle is visibly deposited. It follows that frequent, careful, and precise hydrographic surveys of this unrevealed off-shore area are absolutely essential if any truly scientific plans, or estimates, are to be made about its future, and the nature of the protective works necessary to secure its permanence.

Yours faithfully,
D. H. MACMILLAN,
Commander, R.N.R.

Hydrographic Department,
Town Quay,
Southampton.
17 March, 1958.

Editor's Note: This correspondence originated out of our article "Tidal Model for Southampton Water," which appeared on p. 198 of our issue of 14 February. Another letter, by Mr. C. V. Bowles, appeared on p. 259 of ENGINEERING for 28 February.

Plant and Equipment

INSTRUMENTS FOR INDUSTRY—

There is no doubt that the Physical Society Exhibition is one of the chief occasions of the year for the electronics industry to show its wares. The President of the Physical Society, Professor N. F. Mott, F.R.S., when opening this year's exhibition concluded by saying "Ladies and gentlemen, in wishing the greatest success to research and development in the electronics industry, I have great pleasure in declaring this exhibition open." Although still termed a "scientific instruments and apparatus exhibition," the meaning of the term has changed radically over the period during which the exhibition has been in existence.

Earlier in his speech, Professor Mott had remarked "It, is I am sure, the only instrumental exhibition of large scope run by amateur organisers—if I can call them that." It is one of the fascinating aspects of the Physical Society Exhibition that in the same hall are found exhibits by industrial firms, government departments, university laboratories, and research associations. The following paragraphs mainly describe exhibits shown by industrial firms. Other articles on the exhibition appear on pages 400 and 396 of this issue, and page 373 of the issue of last week.

An electronic dividing attachment for use with a machine for the automatic undercutting of the insulating segments of motor commutators was shown by E.M.I. Electronics Limited. The principle used is as follows. If the image of a vibrating aperture is projected on to a reflecting surface on which a line with poor reflecting qualities is engraved then, when the amplitude of vibration is twice the width of the line, the reflected light will be modulated in a way that will depend on the position of the line in the aperture image. Displacement of the line within the image will produce modulation at the vibration frequency, the amplitude being proportional to the displacement and the phase depending on the direction of the displacement. In the undercutting machine the reflecting surface is the copper of the commutator segments and the poorer reflecting surface of the insulating slots represents the engraved line.

The reflected signal is applied via an amplifier to a null-setting servo that drives the commutator to a position where the insulating slot is central within the image. A cutting wheel is fixed relative to this image and a cut is made when the servo has reached the null position. The armature is then auto-positioned for the next

Obituary

LIEUT.-COL. G. R. S. WILSON, C.B.E.

Chief Inspecting Officer of Railways

Railway engineers in all parts of the country will note with regret the death of Lt.-Col. George Robert Stewart Wilson, of St. Catherine's Cottage, Guildford, Surrey, which occurred suddenly in London on 20 March.

Colonel Wilson, who was appointed Chief Inspecting Officer of Railways, Ministry of Transport, on the retirement of Colonel Sir Alan H. L. Mount, C.B., C.B.E., on 31 July, 1949, was born on 17 April, 1896, and educated at Marlborough and the Royal Military Academy, Woolwich. In November, 1914, he received a commission in the Royal Engineers and went to France in May, 1915. He served in field companies in Flanders and in Macedonia and later commanded a field company in Ireland. In 1921 he was seconded to the Colonial Office for the survey work of the Syria-Palestine Boundary Commission. Subsequently he served with the railway troops at Longmoor until 1924.

From 1924 until 1930, he was engaged in the Directorate of Movements, War Office, and then spent two years in Malta. Afterwards he returned to the Longmoor Railway Training Centre where he remained as an instructor until he retired from the Army in 1935, and was appointed an Assistant Inspecting Officer of Railways in the Ministry of Transport. On the outbreak of war in 1939, Colonel Wilson was recalled to the Army and served as Assistant Director of Railways with the British Expeditionary Force in France until June, 1940, when he returned to the Ministry of Transport and was made an Inspecting Officer of Railways in 1941.

In his capacity of Chief Inspecting Officer of Railways he was responsible for conducting inquiries into the causes of railway accidents and his name was therefore well known to the general public. Among his most recent activities was his inquiry into the collision at Lewisham, in December last, which involved the death of 90 persons. He died before completing his report.

Colonel Wilson, who was a member of the permanent commission of the International Railway Congress Association, was created a C.B.E. in 1953.

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undercutting operation. From the time of loading to the removal of the armature the whole operation is automatic, the time taken to undercut an armature with 28 slots being about 35 seconds. The accuracy of the positional setting depends to a first order on amplifier gain and the width of the setting line or slot. The accuracy of the system used in the undercutting machine is to better than 15 minutes of arc, which in terms of linear displacement represents 0·005 in.

A new isothermal bomb calorimeter was shown by Griffin and George Limited. It incorporates a hand-sealing bomb and is capable of routine determinations on coal, coke, oils, etc., with standard deviations of less than 0·1 per cent. As it was designed for routine use, the convenience of the operator was of primary concern. A work-studied bench has been produced having all the controls built-in for use by a seated operator. It is shown in Fig. 3.

The bomb is made to the design evolved from the researches of the British Coke Research Association. It conforms to the Institute of Petroleum Specification I.P.12 and to B.S.735 and 1016. The body and head are made of stabilised austenitic stainless steel and the clamping rings of aluminium bronze (Crotorite "Z"), to improve the thermal conductivity and to lessen the "chief period." It has a rubber seal to enable the union to be tightened by hand only. The bomb is wide enough to take the 1½ in diameter crucible recommended for coke, anthracite, and other slow burning materials, and the head has solid metal vertically above the crucible so that sealing (due to heat) of a central entry port (and rapid deterioration of the resilient seating of the spring-loaded valve) is avoided. The small condensation, efficient stirring, the control of temperature in the water jacket and the boxing of the jacket, say the company, provide the constant thermal conditions required for accurate calorimetry. The rate of cooling in the Griffin-B.C.R.A. isothermal calorimeter is independent of a difference in temperature between the jacket and the air of as much as 12° C.

A cone and cylinder integrator mechanism was shown by Kelvin and Hughes Limited. The mechanism has been used in a periscope sextant to obtain the average value of altitude, measured by the sextant, over a variable period of time. But it could, say the firm, be used in other applications to integrate any quantity with respect to another on which it is dependent. The device is shown in Fig. 1.

The cone is rotated by a change in altitude and the rotation is transmitted to the cylinder by friction via two balls. The ball carriage is driven uniformly with time. Graduated drums, geared to the shafts of cone and cylinder, record any difference in their rotational movement. At the end of the desired period of time, which may be anything up to two minutes, the cone is rotated until the drums are again lined up as at the beginning of the period—any difference in rotational movement is so nullified. The position of the cone then defines the mean value of the altitude during the time interval, and this value is read from another graduated drum rigidly attached to the shaft of the cone. The same drum shows the instantaneous value of the altitude during the time interval.

An accuracy of 0·03 per cent of the value represented by 360° rotation of the cone is achieved. In the periscopic sextant this represents about ¼ minute of arc.

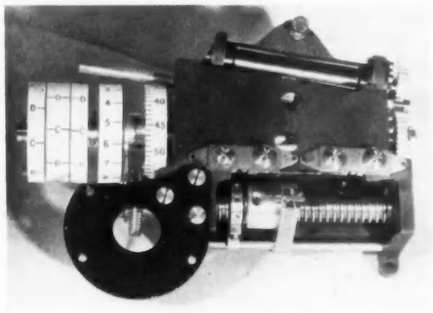
DIGITAL VOLTMETERS

Voltmeters with a digital presentation of the potential measured were on show at some stands this year. Solatron Electronics Limited displayed their type TM728. The instrument compares the unknown voltage with a reference voltage and automatically steps internal selector switches to effect a balance. The setting of the switches is then used to illuminate an in-line display of a digital form, which shows the unknown voltage to four significant figures. A bank of Weston standard cells is built into the equipment, against which the reference voltage may be periodically standardised. The instrument operates over three ranges: 0 to ± 9·999 V, ± 09·99 V to ± 99·99 V, ±099·9 V to ± 999·9 V. The required position of the decimal point is selected by the instrument so that the maximum number of significant figures is always shown. The accuracy and resolution of the equipment are both equal to one digit in the fourth significant place, and readings may be taken up to a rate of one per second. The TM728 will also supply output information suitable for feeding a digital print-out machine.

Ferranti Limited displayed an instrument using a similar principle. It had three digit display with automatic polarity indication and decimal placement. Uniselectors compare the voltage to be measured with an internal reference supplied by mercury cells. Measurements are possible from ± 0·01 to ± 999 d.c. The average reading time is 0·3 sec.

A different principle is used in the digital voltmeter exhibited by Metropolitan Vickers Electrical Company Limited. An internal generator gives a series of pulses, the number being proportional to the voltage being measured. The pulses are counted by a three decade system using multi-cathode discharge tubes which display in a digital form the measured voltage.

Burndept Limited also showed a digital valve voltmeter. The instrument measures d.c. voltages and in principle uses a voltage analogue-to-digital converter. Electronic techniques are used throughout and no mechanical parts are employed. The voltage being measured is used to control the frequency of an oscillator, the output of which is passed through a counter for a fixed interval. The counting is done by dekatron tubes which thus indicate the voltage.



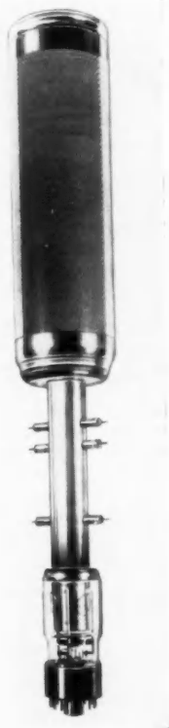


Fig. 1 (Above) The cone and cylinder integrator has been used in conjunction with a periscope sextant, but it has other applications.

Fig. 2 (Left) This tube incorporates a travelling wave deflection system and is intended for frequencies up to 3 kMc/s.

Fig. 3 (Right) The isothermal bomb calorimeter has been designed for routine determinations of high accuracy.

OSCILLOSCOPES

A cathode ray tube designed for single shot and transient recording work was shown by Rank-Cintel Limited. The tube, type VCRX434, has a spiral post-deflection-acceleration system with 30 kV across the spiral. The tube face is 5 in in diameter and is normally supplied with a medium afterglow blue screen. The deflection sensitivity is 60 V/cm, the response being 3 dB down at 1·5 kMc/s. The maximum writing speed is 10^{10} cm/s.

A tube for use at 3 kMc/s (Fig. 2) was shown by Twentieth Century Electronics Limited. The type KR3 uses a travelling wave deflection system and is for millimicrosecond pulse techniques. The deflection system comprises a pair of balanced 120 ohm transmission lines arranged for symmetrical deflection of the electron beam. The input signal is fed in via coaxial connectors, which are also provided for external termination of the lines, or for feed of the undistorted signal to other equipment. The deflection factor is 0·03 V per trace width and the writing speed 10^{11} trace widths per sec. at a beam voltage of 20 kV. The trace width is 0·0015 in.

An apparatus for measuring the resolution of cathode ray tubes was shown by the Royal Radar Establishment, Malvern. Normally the resolution of tubes is expressed by such parameters as the size of the spot or the width of a linear trace. However, because the spot does not have sharply defined edges and the distribution of brightness within it is not known, these quantities can only be defined arbitrarily, and afford rough and incomplete estimates of resolution. The equipment shown overcame the difficulty by measuring instead the extent to which the tube could reproduce small video signals on an intensity-modulated time base.

A small sinusoidal waveform of constant amplitude is used to modulate the brightness of the spot as it moves uniformly across the screen —giving a trace whose intensity varies sinusoid-

Continuing
Instruments for Industry

ally with distance. The amplitude of this intensity variation is measured as a function of " spatial frequency," defined as the number of cycles of modulation per unit length of trace. In this way the " spatial frequency response " of the tube—somewhat analagous to the frequency response of an electrical system—is found. This enables the resolution of the tube to be specified precisely, in a way which allows its performance in intensity-modulated displays to be predicted.

In the apparatus the modulating and scanning frequencies are chosen to give a pattern which drifts slowly along the trace. An image of the trace is formed across a narrow slit, and the light passing through the slit measured photoelectrically to give a reading proportional to the sinusoidal variation of intensity of the trace. The spatial frequency of the pattern is varied by changing the scanning velocity. The response of cathode ray tubes to spatial frequencies between 2 and 200 c/cm can be measured to an accuracy of a few per cent of the maximum (zero frequency) value.

E.M.I. Electronics Limited showed a measuring oscilloscope incorporating a distributed Y amplifier and signal delay line, with a bandwidth from d.c. to − 3 dB at 50 Mc/s.

MICROWAVE COMPONENTS

W. H. Sanders (Electronics) Limited produce a range of signal generators to provide oscillation over the band 2kMc/s to 12kMc/s. On show at the exhibition was the XT.314, used to measure the performance of receivers and for general laboratory measurements in the frequency range 7 to 12 kMc/s. A piston attenuator provides a calibrated output adjustable between 10 dB and − 100 dB at a 50 ohm socket on the front panel. An internal power-set control is provided to establish a reference level of 1 mW. Facilities are provided for internal square and pulse modulation at a frequency of 3 kc/s, together with a synchronising signal output.

Wayne Kerr Laboratories Limited are developing a series of wavemeters for the Royal Aircraft Establishment for the range 1-40 kMc/s. Three of the latest models were shown at the exhibition. The cavities operate in the E_{010}-EH hybrid mode and cover 0·9-2·2, 10-18, and 26-40 kMc/s. The firm claim that the resonators are free from undesired responses below and within the frequency ranges. The accuracy of frequency measurement is better than 1 in 3,000 but can be as high as 1 in 10,000 if the coupling is reduced below standard level. The standard level is such that an input of 50 microwatts of r.f. power produces 1 millivolt d.c. or pulse across 5,000 ohms. Each wavemeter contains a crystal rectifier. The rectified signal is fed to an indicator where it is chopped (in c.w. conditions only) by a relay, and amplified and used to operate a " magic eye ". The eye will close for an input signal of 1 mV.

Measuring equipment for 75 kMc/s was exhibited by Mullard Limited. The company claim that the equipment comprises a more or less complete assembly of measuring apparatus for 4 mm waves. The oscillator is a 100 mW klystron tunable over a total relative frequency range of about 15 per cent. The tuners are of the sliding screw type.

The frequency can be measured with a transmission cavity, excited in the TE_{011} mode. Power measurements can be carried out with a thermistor in a bridge circuit. Impedances can be measured both with a standing wave indicator and with a bridge circuit. The standing wave indicator is of the slotted line type; care in machining has resulted in an apparatus with a residual standing-wave ratio of about 1·02 and a maximum detectable standing-wave ratio of about 100. The alternative method makes use of a hybrid tee (which need only be symmetrical) and a direct reading variable impedance of simple construction. The accuracy of the instrument is of the order of a few per cent.

In Parliament

BRITANNIA AIRCRAFT

A number of matters of transport and aviation interest were raised in the House of Commons last week. Mr. W. Coldrick (Labour/Co-operative) referred to the Government's authorisation of capital expenditure on Britannia aircraft by the British Overseas Airways Corporation and asked the Minister of Transport and Civil Aviation what reports had been received regarding the aircraft's profitability during the period that it had been in service. In reply, Mr. Harold Watkinson said that the Corporation informed him that, on the Australian and South African routes where Britannia aircraft had been in operation for a full year, their profits had increased substantially. On the routes to the east, where these aircraft had been brought into service more recently, there had been, at the same time, a general falling off in traffic. This decline was unconnected with the introduction of the Britannias, and it was too early, therefore, to measure the success of the aircraft on these routes.

SOUTH AMERICAN AIR SERVICES

It was announced by Mr. Watkinson that the British Overseas Airways Corporation accepts the main conclusion of the recent survey party, namely that there was likely to be sufficient traffic in future to justify the resumption of operations to Brazil, Uruguay, Argentina and Chile, although losses would be incurred at the start. Subject, therefore, to the Corporation's overall financial situation at the time, they intended to re-open their route to these countries as soon as sufficient aircraft capacity became available. He told Mr. Anthony Hurd (Conservative) that this position was not likely to arise before some time next year.

TRANSATLANTIC AIR FARES

Mr. R. Gresham Cooke (Conservative) inquired whether the Minister had now given his approval to all the decisions of the International Air Transport Association with regard to transatlantic passenger fares, and what consideration had been given to introducing some element of competition in the fares of scheduled services on that route. He stressed the position ruling at the present time, whereby the single fare from New York to San Francisco was 80 dols., while the same distance, from London to New York, carried a single fare of 250 dols. The discrepancy was brought about by the international agreement under the Association. Was there not a case for letting a little fresh air of competition into the North American air routes, in spite of the activities of the Association?

It was suggested by Mr. Frank Beswick (Labour/Co-operative) that the absence of competition was due to international co-operation and planning, and that a fine service was being provided which was much cheaper than it was ten years ago. Mr. Watkinson replied that he had given his approval to the decisions of the International Association. The practice had been accepted by governments in the past that a system of agreed fares was in the best interests of air transport. He welcomed competition as a means of reducing fares and would look at what had been said. The new economy fare on the North Atlantic route represented a considerable drop in charges.

BACKWARD-FACING AIRCRAFT SEATS

A strong plea was made by Mr. Gresham Cooke that, in the interests of safety, the Minister should give a general direction to British European Airways and to the B.O.A.C. to provide a proportion of backward-facing seats in aircraft, so that passengers might choose such seats if they wished. He asked what consideration had been given by the International Air Transport Association to the question of providing such seats in scheduled airliners and whether the Minister would confirm, or not, that all or a great proportion of the 22 survivors in the recent Munich air crash had occupied seats of that kind. A number of passengers had a feeling that rearward-facing seats were rather safer than forward-facing seats and the present time would appear a good one for encouraging the Corporations to provide some, perhaps 50 per cent of the total number of seats, in their aircraft.

Mr. Watkinson said that the facts about the Munich crash would come out in the forthcoming report. The International Association had considered the question from time to time, but did not feel that operators should be obliged to have a proportion of backward-facing seats. In the absence of international agreement, he was not prepared to issue a direction to the Corporations. Airlines could make their own choice and it was his view that they should be able to do so. In fact, modern British aircraft were now being fitted so that the seats in them could very easily be made to face either forwards or backwards.

Railway Track Pollution

Potential dangers arising from the discharge of untreated sewage in public places were referred to by Dr. Somerville Hastings (Labour). He pointed out that a solution of this problem had been achieved in regard to air travel and wanted the Minister of Transport and Civil Aviation to set up a special committee to inquire into the making of improvements in the lavatory services in long-distance trains. This, Mr. G. R. H. Nugent, Joint Parliamentary Secretary to the Ministry, declined to do. He said that any such action was a matter for the British Transport Commission. They had recently caused the whole subject of track pollution to be investigated by a committee of experts and were now considering certain modifications in existing methods, in accordance with the committee's recommendations.

Conference on Sea Law

Difficulties arising from some shipping firms throughout the world using flags of convenience came before the House again. Major P. H. B. Wall (Conservative) wanted to know what steps would be taken by the United Kingdom's representatives at the recent Conference on the Laws of the Sea, at Geneva, to press for a closer association between a merchant ship and her country of register, so as to minimise the threat to all maritime nations caused by shipping using flags of convenience. Mr. Airey Neave, the other Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, replied that the delegation had already suggested that the conference should endorse the principle of there being a genuine link between States and ships, and that the problem should be referred to other appropriate international bodies for detailed examination.

Rural Electrification

The question of making government grants for the electrification of farm buildings under the farm improvements scheme was brought up by Mr. A. M. F. Palmer (Labour/Co-operative), who argued that grants should be given in cases where the farmer made his financial contribution towards the capital cost of the electricity service in quarterly instalments and not by means of a single lump sum. He felt that the present system cancelled out to a great extent much of the advantage which the farm improvements scheme gave to rural electrification. Mr. J. B. Godber, Joint Parliamentary Secretary to the Ministry of Agriculture, said that arrangements existed for the provision of a financial grant to farmers who paid by a limited number of instalments. Consideration was being given as to whether the grant could be payable to farmers who arranged to pay on a fixed-charge basis without time limit. There were difficulties in some areas, but they should not be exaggerated.

The Human Element

Getting at the Facts

The March issue of the United Patternmakers Association carries an article on the use which is made by the United States trade unions of economic research. It shows the care which is taken both at inter-union and top official level in the unions over there to brief those who have to negotiate. This development in America is one of the principal differences between union procedure before negotiation in that country and in the United Kingdom.

The American unions employ professional economists or bring them in as consultants. This has rarely if ever happened here. Why should this be so? Part of the reason lies in tradition, part in the fact that unions in this country have been reluctant to tell management how to do their job—a point on which the United States unions have never been backward. They have for long thought that their job of getting more of the cake out of employers included advising on how to increase the cake.

It is probably only a question of time before unions in this country go at least part of the way in the same direction. The growing complication of industrial techniques, the increased use which employers make of economic arguments and the realisation that a union's case can be much strengthened by the careful marshalling of arguments based on statistics correctly interpreted are all pushing the larger unions in the direction which the Americans have already gone. So far, the trade union movement has preferred to train its own economists (partly because they are cheaper) but the time may not be far off when the unions feel that they should have the best, if only on a retaining basis.

Teachers and Research

A plan has been submitted by the American Society for Engineering Education to the American Government to increase the supply of engineering teachers of which there is a serious shortage in the United States. Basically the idea is to encourage engineers after graduation to take up fundamental research and teaching. The idea would not be a very revolutionary one in this country where we emphasise the importance of fundamental research and its relation to good academic teaching. It is different in America where, especially in engineering, post-graduate work in an academic environment is not attractive to most men—largely because of the high rewards in industry.

The idea is to increase the size and scope of awards from the National Science Foundation for students of varying ability and at different stages of their studies. It would include a new programme of awards under the N.S.F. to increase financial aid to graduate students who combine research with teaching. The Society believes that the United States faces a shortage of nearly 1,000 engineering teachers.

Criminal Wealth

Young offenders in his area were recently described by the Chief Constable of Swansea, Mr. D. V. Turner, as " youths in the 15-17 age group, whose inflated wages have given them an exaggerated idea of their value to the country's labour force." Dismissing the theory that crime was primarily a factor of poverty and unemployment, Mr. Turner contended that nowadays " much wrongdoing by juveniles has its origins in boredom, and a craving for the effortless entertainment provided in such generous measure by the cinema, television and radio."

There is a great deal of truth in the statement that young people have grown up to have everything ready-made and have not therefore the satisfaction of creating their own entertainment. But are they so helpless in forming their opinions as Mr. Turner suggests? The youth of to-day, like that of the previous generation or any other, needs to pass through the difficult two or three years when a boy is neither a youth nor a man. " Man-like " deeds are attempted and it is then that many habits, smoking, for example, or social drinking, are contracted. Poverty, or wealth, alter the psychological situation but very little, though young people at the extremities of the scale may feel freer from social conventions and are therefore more liable to break them.

Workless Seamen

Unemployment among merchant seamen is something quite new in the lives of most of them. Until recently there was no industry where the shortage of manpower was so critical. The recession which has caused over 100 ships to be laid up around our coasts has transformed the situation. It is estimated that some 5,000 are out of work, out of a total labour force of 150,000 officers and men. This is a 3·3 per cent unemployment figure, substantially higher than the national average.

The recession should considerably strengthen the industry's establishment scheme, which was launched after the war to take the casual element out of seafaring. By joining the establishment, seamen are given preference for available work and entitled to unemployment benefit in return for a contract renewable every two years, binding them to accept work offered. The industry permits a maximum of 70 per cent of seamen to be established, to retain reasonable flexibility. At present the figure is about 50 per cent and will probably rise quickly to the limit allowed. Established men need only wait for a few days for a ship and the incentive to join will be strong, especially as benefits up to £6 16*s.* a week are paid in addition to normal unemployment benefit. On the other hand, owners cannot be expected to show the same keenness to fill their books and incur the liability as they were a year ago. Entry is now restricted in certain departments (though certificated engineer officers are still very scarce) and the situation is being carefully watched.

Pay, Productivity and Prices

The Association of Supervisory Staffs, Executives and Technicians is reported to be preparing a plan on an industry-wide scale to link wages to prices and productivity. The first move has been made in the air-transport industry, but it is thought to be under consideration for extension to engineering, chemicals and textiles.

The idea is to offer employers a basis of a simple increased percentage in pay or a formula relating the claim to the estimated increase in productivity with allowance made for a decrease in prices to the user. The idea is certainly an enlightened one. The union hope that it will set an example to others.

Working out such a formula will involve the union in a thorough examination of the accounting and economic situation in each industry. Increases in productivity are not as easy to measure as might appear when one gets away from crude statistics and the complication of adjusting the calculation for a price change in favour of the customer will be a further complicated statistical exercise. These matters apart, however, such formulae would give the union a big interest and incentive to raise productivity and probably begin an era of pressure from the union on management to raise its efficiency. This is the kind of development (touched on in another note) which might provide a useful stimulus to management in this country. Not a few managements would benefit from it.

Too Many Miners

The fall in demand for coal is threatening unemployment in the industry. Despite the cold winter, the output of deep-mined coal is running at some 2 million tons below the 1957 level and the Miners Union are asking the National Coal Board to take emergency measures to prevent unemployment. The main request is for a substantial reduction in opencast operations, but the union will also ask the N.C.B. to minimise the closure of uneconomic pits and allow the movement of miners to other pits, in order to avoid large pockets of redundancy. They will press for cuts in oil imports during the period of the coal surplus and for an expansion of exports, particularly to the Continent as the long-term contracts with the United States expire.

The N.C.B. are unlikely to agree to measures so clearly designed to maintain employment at the expense of almost everything else. Opencast mining is one of the Board's most profitable operations. The rapid closing of uneconomic pits will almost certainly be considered a solution to the present troubles and the union's proposal that they should be kept open as a special measure will almost certainly meet resistance.

Miners' leaders give the impression that they have gone rather farther than the situation demands. The margin between sales and output potential is relatively very small and consists mainly of small coal. High labour costs are forcing coal prices upwards to a point where demand is checked. Even in the short run the men's interests would appear to be better served by measures which promote efficiency rather than the reverse.

Apprehension at Bristol

Fears that the present redundancy at Bristol's Filton works and London drawing office (400 and 200, respectively) will be increased to 4,000 this year and that there will be a further similar run down next year, were expressed by the Association of Engineering and Shipbuilding Draughtsmen last week. According to the local branch of the Association, a " crisis of the greatest magnitude faces the 25,000 workers of the Bristol Aeroplane Company's group of factories in the immediate future," due to lack of orders for the Britannia airliner.

The Association's Bristol members suggest that the Government should maintain production of the airliner and that a joint industrial council should be set up for smooth planning of changes in the aircraft industry. One of their contentions is that the Government, " as the prime mover in aircraft projects during and since the war," should give the industry time to adjust itself to changes in Government defence and economic policy: about two years' notice of intention is suggested. In this instance, the Association press for orders from B.O.A.C. or Transport Command to maintain the Britannia's production line to provide time for further export sales efforts and the planning of new projects.

The fact that draughtsmen should be giving both the warning and the lead adds to the credibility of their statements—they, more than most, are not easily spared, particularly when the product has a high design content. Bristol's comment cautiously that the Association's estimates of future redundancy were " not supported by the facts of the situation as assessed by the company."

Special Article

PLANETARIUM FOR LONDON

With an outside diameter of 81 ft, the London planetarium has the largest copper-clad dome in the British Isles.

The timing of the opening of the new planetarium in London during the International Geophysical Year, with public interest focused on the skies as never before by the launching of the earth satellites, could hardly have been better chosen. The initial presentation of the first programme, "The Earth is our Spaceship," was given before an invited audience on 19 March, and was attended by H.R.H. The Prince Philip, Duke of Edinburgh. On the following day the planetarium was opened to the public.

The planetarium is built upon the site of Tussaud's cinema in the Marylebone Road, London, N.W.1, adjacent to the waxworks. Although sponsored in the first place by Madame Tussaud's Limited, it is to be operated as a separate company, the London Planetarium Company Limited, with Dr. H. C. King, Ph.D., M.Sc., F.B.O.A., F.R.A.S., directing operations. The wonderful Zeiss projection equipment has already been described in detail in an article by Dr. H. C. King in the 1 March, 1957, issue of ENGINEERING. Briefly, the changing patterns of the constellations and the planets, as the earth turns daily on its axis and orbits yearly around the sun, can be shown to the audience in a matter of minutes; not only from the latitude of London, but from any place in the world; not only in the late 1950's, but at any time in the distant past or the remote future. The audience can be shown a shower of meteors, the waxing and waning of the moon, and the changing colours of the sky as the sun sets and rises.

The drawing of the Zeiss projector on the opposite page is reproduced from Dr. King's article. The two fixed-star globes at opposite ends of the dumb-bell assembly each house a 1,000 watt lamp, 16 projectors and photo-engraved plates and between them some 9,000 fixed stars can be projected on to the hemispherical screen that forms the roof of the auditorium. The 42 brightest stars and the three variable stars Algol, Mira Ceti and Delta Cephei, are produced by individual projectors located on the star-globe baseplates, where are also situated two Milky-Way projectors. Gravity-operated mechanical shutters in front of each projector reduce the light thrown by the projector progressively, and finally cut it off completely, as the stars dip towards the horizon. The two small globes at the extremities of the dumb-bell house projectors for the constellation names and for the precession dial.

To depict the motions, relative to the fixed stars, of the sun, the moon and the five planets visible to the naked eye, mechanically-linked movable

A typical scene in the London planetarium: latitude 64, in the small hours of midsummer's day 1958, the "eye" of the constellation Cygnus the Swan crosses the meridian.

projectors are housed in the two cylindrical frameworks of the dumb-bell assembly inboard of the star globes. The projectors for Saturn, the sun and the moon are in the upper cage and those for Mercury, Venus, Mars, and Jupiter in the lower cage (as shown in the illustration).

The drive for the planetary motions is by three motors which can be run singly or together, in the same or opposite directions, to enable a year's events to be depicted in twelve minutes, four minutes, or eleven seconds. There is also an additional projection unit (separate from the dumb-bell assembly) for "transporting" the audience to a station "far beyond the orbit of Saturn" so that they can observe the five planets and the earth orbiting about the sun. This solar-system projector is not illustrated. Two other small globes mounted on the dumb-bell house six projectors each for projecting on to the dome the ecliptic—the apparent easterly path of the sun over the course of the year—and other reference lines.

In all, the Zeiss instrument incorporates 180 projectors controlled by seven electric motors, 230 ball bearings, and complex precision gear trains. The dumb-bell is 13 ft 9 in long, and the instrument on its lattice framework weighs over 2 tons. In view of the high precision workmanship and the years of development that have led to the making of this complex and superb piece of engineering, its cost of £70,000 seems comparatively modest.

The apparent motion of the stars and the planets as the earth turns on its axis once in 24 hours is reproduced by rotating the entire dumb-bell assembly about the vertical axis *Pn-Ps*. The precession of the equinoxes—the shift of the direction of the earth's axis, which takes 25,800 years for a complete cycle—is brought about by rotating the dumb-bell about its own longitudinal axis *Qn-Qs*. It is this motion that enables the star patterns from prehistoric times to the far distant future to be visualised. Changes in the spectators' latitude are brought about by rotating the dumb-bell about the horizontal W-E axis.

The lower illustration opposite shows a typical scene in the planetarium; the skyline of London is depicted around the base of the dome, and here we are facing south. The sky picture, however, is not as seen from London, but from latitude 64, in the small hours of midsummer's day, 1958. The "eye" of the constellation Cygnus the Swan is just crossing the meridian; slightly to the right of the projector, the moon is sinking towards the horizon. The constellation outline and the grid lines shown in the illustration are not permanently features of the "sky" but can be thrown at will on to the dome by the commentator, who operates the projector, to illustrate particular points of his discourse.

During the "performance" there is an accompaniment of subdued music; rather poorly reproduced by a tape recorder, this is at present the one unsatisfactory feature of the programme, but one that it should be easily possible to remedy.

The dome-shaped auditorium, which is carried on columns above ground level, seats 550 people. The Zeiss projector, in the centre, is mounted on a lift (not yet working), and when not in use it will be lowered from the auditorium to ground floor level where it will be visible within a glass-sided cage.

When a performance is about to commence, the projector will rise up into the auditorium like a cinema organ; but the "organist" will be already seated at the back of the auditorium at a console at the northern end of the dome, from which he controls remotely the motions of the instrument and the lighting effects. Before the commentator causes the sun to set, the spectator is aware that he is sitting below a white panelled hemispherical ceiling supported on a framework of longitudinals and transverse members; as the lights dim and darkness falls, quite suddenly he is no longer under a roof but gazing into boundless space; the effect is quite remarkable.

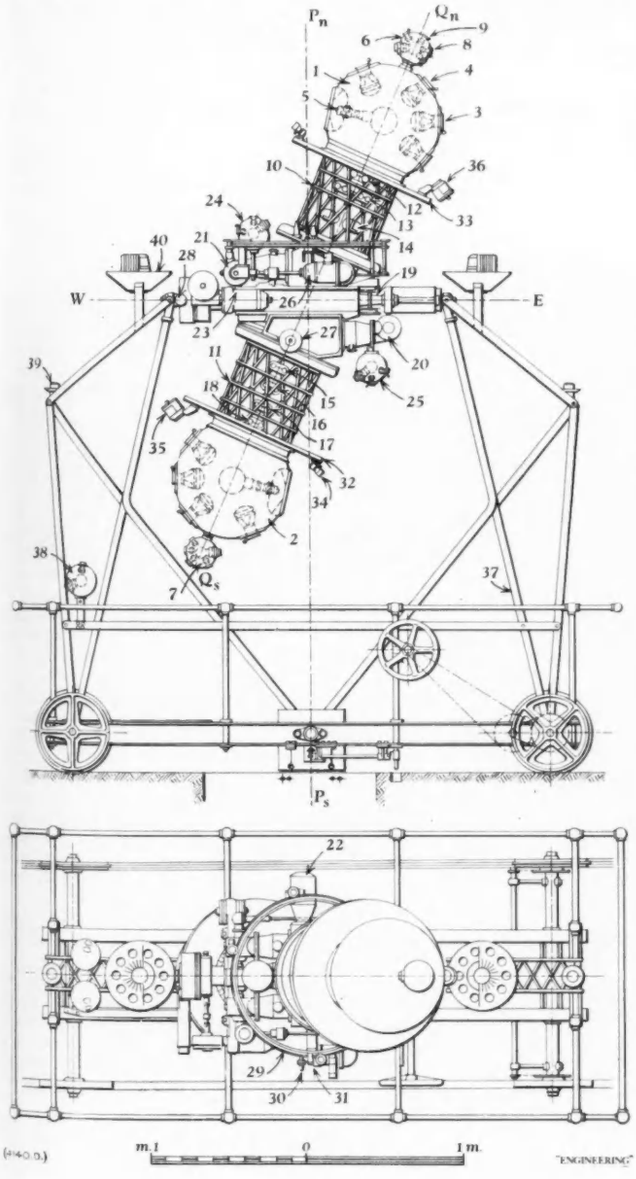
The projection dome, in fact, is 67 ft in diameter, made up of preformed aluminium sheeting perforated with 20 holes per sq. in for acoustic reasons—and also serving the ventilation system. To ensure a dust-free atmosphere within the projection theatre, the ventilation system provides for eight changes per hour of filtered air, and the air pressure within the dome is maintained at the not uncomfortable figure of 2 lb per sq in above the ambient pressure.

The dimensions of the aluminium dome had to be accurate to within ¼ in to ensure that the projected picture was correct. This inner dome is contained within an outer structure comprising two 3 in thick reinforced concrete domes separated by a 3 in space filled with Fibreglass. Between the inner concrete dome and the aluminium projection dome is a thick blanket of sound-absorbing material; and on the outside of the outer concrete dome is a 1 in layer of cork over which is a thick layer of bitumised felt and finally the copper cladding, which, when it weathers, will become one of London's showpieces. With an outside diameter of 81 ft, it is the largest copper-clad dome in the British Isles. This elaborate sound proofing construction is essential because the Marylebone Road site is a noisy one; and it has proved entirely successful in shutting out all traffic noises.

In addition to airborne noise, however, the structural designers had to ensure that the building was completely unaffected by ground-borne vibration—the underground railway runs across one corner of the site just below the surface. Accordingly, a heavy structure has been adopted, weighing more than 2,000 tons, and it is supported on 48 piles driven more than 50 ft below ground level. The dome itself is carried on 12 columns springing from a concrete grillage supported by the piles.

The architect for the planetarium was Mr. George Watt, A.R.I.B.A., the consulting engineers R. Travers Morgan and Partners, and the general contractors were A. J. Wait Limited, Malden, Surrey.

The planetarium is open seven days a week, and presentations lasting some 40 minutes are given on week days at 11.30 a.m., 3.30, 6.30, 7.45, and 9.00 p.m., also at 4.45 p.m. on Saturdays. On Sundays and on Good Friday, the times are 3.30, 4.45, 6.30 and 7.45 p.m. On Bank Holidays, performances are as on Saturdays with additional showings at 10.15 a.m. and 2.15 p.m. Patrons are asked to be in their seats 10 minutes before the performance starts. Advance bookings may be made by personal application or by post for all the evening performances and for the 3.30 and 4.45 p.m. performances on Saturdays, Sundays and Bank Holidays. The prices of admission are 2*s*. for weekday mornings, 3*s*. for weekday afternoons, and 4*s*. for all evening, weekend and Bank Holiday presentations.



The Zeiss "dumb-bell" projection equipment.

(1 and 2) Two fixed star globes
(3) Projectors, 16 per globe
(4) Mechanical shutters, 16 per globe
(5) 1,000 watt lamp, one per globe
(6 and 7) Two globes for constellation names and precession dial
(8) Projectors, 15 per globe
(9) Mechanical shutters, 15 per globe
(10 and 11) Two planetary frameworks with double projectors and planetary mechanisms
(12) Mechanism for Saturn
(13) Mechanism for sun with aureole
(14) Mechanism for Moon
(15) Mechanism for Mercury
(16) Mechanism for Venus
(17) Mechanism for Mars
(18) Mechanism for Jupiter
(19) Centre piece on cradle
(20) Two motors for diurnal movement
(21) Three motors for annual movement
(22) One motor for precessional movement
(23) One motor for polar altitude variation
(24 and 25) Two globes with 6 projectors each for equatorial grid reference system and ecliptic, and for two pole arrows
(26) Projector for year counter
(27) Mechanical precession counter
(28) Optical polar altitude reader
(29) Lattice ring
(30) Vertical circle projector
(31) Hour circle projector
(Above three items comprise equipment for demonstrating the mean sun and the nautical triangle)
(32 and 33) Two ruffs between fixed-star sphere and planetary framework
(34) 45 special projectors for the 42 brightest fixed stars and the three variable stars Algol, Mira Ceti, Delta Cephei
(35 and 36) Two Milky-Way projectors
(37) Carriage frame
(38) Two spheres with two projectors each for meridian
(39) Two horizon illuminations for morning and evening
(40) Two dome illuminations providing white and blue light

Special Article

FUNDAMENTAL TRAINING IN NUCLEAR POWER

Postgraduate Course at Imperial College

By Professor J. M. Kay

In the early days of atomic energy the engineers at Risley, Harwell and the other establishments were obliged to learn about the basic principles of nuclear processes in the actual course of designing and building the first nuclear reactors and associated process plants. There is still no better way for an engineer to extend his range and understanding than by learning on the job. With the growth in size of the atomic energy project, however, it has become increasingly difficult for newly recruited young engineers to gain knowledge of more than a very small part of the field in this way. For this reason a postgraduate course in nuclear power, presented from the engineering point of view, was started at Imperial College, London, last October.

If there is one characteristic feature of nuclear power station engineering, it is the importance of the role of the design engineer. Experience has shown that it is essential to have a co-ordinated team of mechanical, civil, electrical and chemical engineers in charge of any large design and constructional project such as a nuclear power station. The senior members of a design team of this character must have wide scientific knowledge combined with sound engineering judgment and an ability to handle large constructional resources. It is not possible to turn out a ready made design engineer direct from a university course to meet these requirements. It is possible, however, to provide a reliable foundation in presenting the basic principles of nuclear energy and in teaching the approach to design engineering in a postgraduate course.

Because of the rapid pace of scientific discovery and the equally rapid development of new engineering techniques, it is essential for the design effort in nuclear power to be supported by adequate research and development resources. There must therefore be a corresponding team of applied scientists, particularly metallurgists, physicists and chemists, and also development engineers, working in close co-operation with the design team.

With these considerations in mind, the postgraduate course in nuclear power at Imperial College has been planned primarily to meet the needs of graduates in mechanical, civil, electrical, and chemical engineering who wish to enter the field of nuclear power plant design and construction. The course is also open, however, to applied scientists who are interested in research and development associated with nuclear reactors and nuclear processes. The lecture syllabus is divided into two main groups. The backbone lecture courses, intended for all students, cover the following subjects at postgraduate level:—

Nuclear reactor theory.
Applied nuclear physics.
Fluid mechanics and heat transfer.
Strength of materials.
Radiation hazards and protection.
Nuclear fuel technology.
Design and construction of nuclear reactors.

Optional lecture courses are also given on the following subjects which are intended to suit the particular needs and interests of different groups of students who have graduated in different basic branches of engineering or applied science:

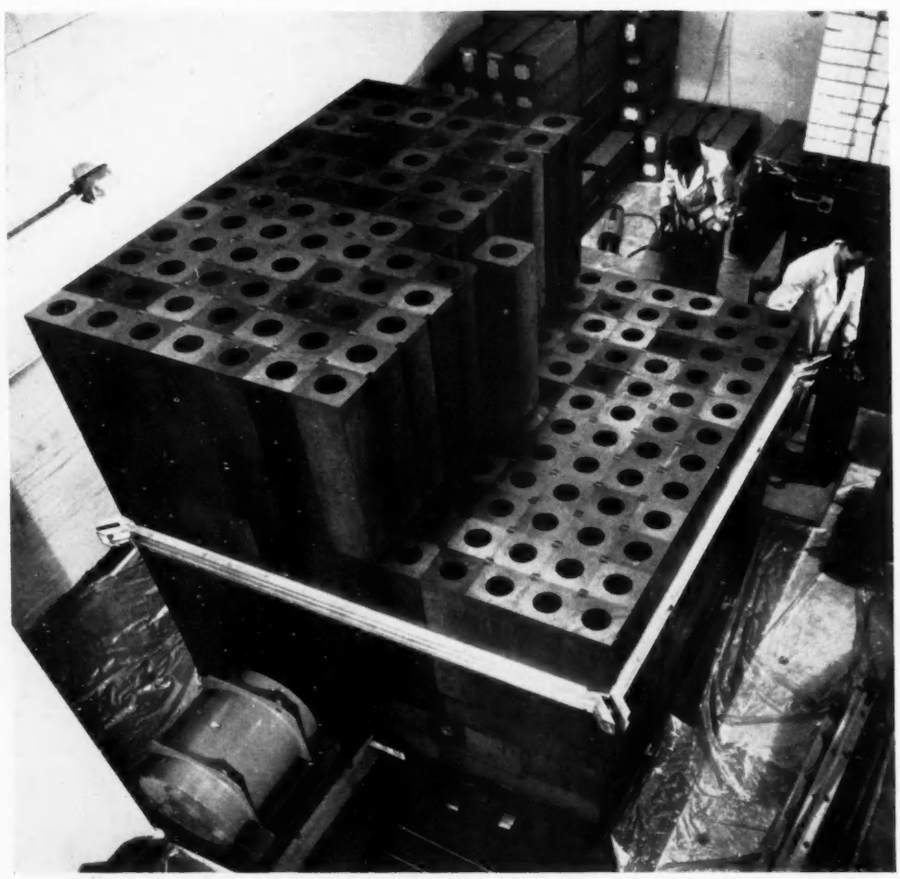
Advanced reactor physics.
Advanced heat transfer.
Stress analysis and properties of reactor materials.
Thermal design of nuclear power plant.
Reinforced concrete structures.
Reactor kinetics, control, and instrumentation.
Chemical technology of nuclear power.
Isotope separation.

Other optional lecture courses will be added as the engineering applications of nuclear energy develop. At the appropriate time, for instance, courses will be given on such different topics as marine propulsion, the industrial use of radiation, and on thermonuclear reactions.

A special feature of the present course is the inclusion of a design study of a complete nuclear power station or related process project. The design study extends over the whole academic year and it is used to illustrate the way in which the various basic branches of engineering and applied science must be integrated in relation to the needs of an actual constructional project. A high degree of reality is maintained in this study which is started off with a specific site and with a full discussion of siting and constructional aspects. Each student is given a particular and detailed part of the design to handle during the year. Special design lectures and discussions are held regularly to progress the work and to keep the whole project under constant review. Visits to engineering works and constructional sites are also arranged during the year. In all these activities, close co-operation is maintained with the U.K.A.E.A., with the principal engineering consortia, and with the C.E.G.B. In many cases lectures are given on special subjects by members of the engineering staff of some of the leading firms.

Experimental work is being built up steadily to supplement the lecture syllabus. Demonstrations and experiments are available on the detection and measurement of nuclear radiations, the use of neutron and gamma sources, counting equipment, neutron diffusion and slowing-down, and shielding. A sub-critical natural uranium graphite exponential assembly has been built for demonstration and research purposes, and the accompanying photograph shows this assembly under construction. A comprehensive analogue computer has been installed for investigations into reactor kinetics and control problems. A large heat transfer rig is being built to enable some of the more fundamental aspects of heat transfer between fuel element surfaces and the coolant gas to be studied experimentally.

One of the incidental aims of this course is to stimulate interest in university engineering circles in the field of heavy engineering. During the last decade the more fashionable, but possibly ephemeral, subjects in the light engineering field have tended to deflect attention away from such important matters as steam turbines, steam plant design, pressure vessel problems, and general heavy mechanical engineering design. It may also be noted that the attitude of mind required in the engineering of nuclear power is not essentially different from that required in the case of other large process plants such as "conventional" thermal power stations, oil refineries, large chemical plants, and metallurgical processes. Even in the absence of a requirement for nuclear power, there would still be a need for a postgraduate course in large-scale *process engineering* presented from the constructive rather than the analytic point of view. Such a course would be very similar to the present course in nuclear power at Imperial College.



A sub-critical natural uranium graphite exponential assembly has been built at Imperial College.

(*Further reference to the course appears on page 399 of this issue.*)

Companies in the News

Changing Pattern of Ownership

The importance of the private investor in industry has rarely been underlined so clearly as in the annual report of Associated Electrical Industries. The analysis of ownership of A.E.I. equity in two years, 1947 and 1957, shows that individual shareholders are still in a majority despite a large increase in the importance of the institutional investor such as insurance companies and pension funds. In 1957 individuals held 54 per cent of the total, the average holding being £272 and the number of shareholders in this category 66,853—more than the group's total number of employees. Percentage comparisons with 1947 are not easy, due to the existence in that year of a large class of "limited companies and other co-operative investors" who accounted for 41·8 per cent of the total in that year. This proportion dropped to 4 per cent in 1957 while the proportion held by individuals rose from 36 per cent to 54 per cent. In all probability the two categories are related and it is therefore difficult to conclude whether the individual shareholder is increasing or decreasing in importance. In all probability he is a decreasing influence in capital formation though still a very major one.

The small saver appears in another form as a source of industrial finance, through the investments made by insurance companies, investment trusts and pension funds whose funds are to a large measure provided by the savings of ordinary people. Insurance companies increased their holding in A.E.I. from about 7½ per cent in 1947 to nearly 19 per cent last year. Pension trusts increased theirs from 0·3 to 2·4 per cent. The group thus emerges from this analysis as one in which finance is provided on a most democratic basis, by large numbers of small savers either directly or through the institutions in which their savings are invested.

Copper and Aluminium

Despite the poor prices at present obtainable for base metals, the copper industry's spokesmen remain confident about the long-term prospects for their metal. The latest statement comes from Mr. R. H. Glover, chairman of Anaconda, at the convention of International Union of Mine, Mill and Smelter Workers at Denver in the United States. Mr. Glover said that European demand for copper continued fairly buoyant and the demand had been met only because American producers had reduced their deliveries in the domestic market. According to Mr. Glover the low price ruling in America does not justify producers in that country making a special effort to increase production to meet the European demand. They are meeting it only in so far as this can be done from stocks carried over from 1957. Even in the United States, however, stocks with fabricators were so low that the latter were demanding immediate delivery on new orders. The trouble was that the orders were still small ones. He did not think that it would require much of an increase in business to increase the price of copper and raise output.

In aluminium, there has been a good deal of re-assessment of short-term prospects in the light of the large amount of new capacity which has been coming into operation in the United States and the dumping of aluminium ingots by Russia in western Europe. Nevertheless, an industry which in the first 50 years of its existence since the turn of the century has expanded its capacity at the rate of about 10 per cent per annum, and has only recently cut down its expectation of annual increase to 5 per cent, is probably inevitably still expansion-minded. The Northern Aluminium Company, which is the prefabricating subsidiary from ingot in this country of Aluminium Limited of Canada, has announced plans to spend £10 million over the next four years. Nearly £8 million of this is for new plant and equipment and most of the programme will involve the expansion of the aluminium mills at Rogerstone near Newport (see p. 410). Annual output will be raised from 50,000 to 75,000 tons. The augmented mill will make a wide range of rolled products including wider and longer aluminium plate, and medium-strength alloys will become available for shipbuilding, chemicals and atomic energy.

Printing and Heating

Two engineering companies celebrated anniversaries last week. The first, George Mann and Company Limited, a company of the Vickers Group and one of the largest producers of offset printing machines in the world, began as an association of five men 80 years ago. In 1903 the company constructed the first commercially efficient rotary offset machine, though it was built for printing on tin. The first successful British-built rotary offset machine for general printing work was the subject of a master patent granted in 1908, and during the next 25 years 2,000 machines to this standard design were installed throughout the world.

In 1910 the company produced the first successful rotary offset machine capable of printing two colours in one operation and also of perfecting, that is, printing on both sides of the sheet. For over ten years this machine was without a competitor in the field of offset multi-colour work.

The second company referred to above is William Steward and Company Limited, electrical engineers and contractors, who celebrated their silver jubilee. The company are particularly concerned with industrial installation and specialise in electrical systems for heating and ventilating plants, including oil-fired burners. They were responsible for the complex wiring system, totalling some 25 miles, and the connection of the instruments and controls for the heating and air conditioning plant in the House of Commons. In 1953 the company's service and installation departments were engaged on day and night emergency work in connection with the East Coast flood disaster, involving the complete renovation of about 700 electric motors and extensive re-wiring of factory premises.

More Factories for Northern Ireland

The Northern Ireland Development Council were able to announce this month two further successes in their campaign to attract industry to Northern Ireland. On 12 March, it was stated that the Ministry of Commerce had agreed to build a standard factory of approximately 25,000 sq. ft for Tolimit Gauges Limited, on the Government Factory Estate at Dunmurry near Belfast. Two days later came the announcement that Imperial Chemical Industries intended to establish a unit in Northern Ireland for the spinning of Terylene polyester fibre.

The first project is relatively small, involving an initial labour force of 75, but the company, who at present produce precision gauges and automation equipment at Fulham, chose Northern Ireland because it offers an adequate reserve of labour for future development, and it is expected that within two years employment will rise to about 140, including 100 men. The Dunmurry estate is the fourth to be developed by the Ministry of Commerce since the war. In January it was announced that Wandleside Warren Wire Limited, an Anglo-American company, would occupy the first factory of 70,000 sq. ft on the estate. A point made by the managing director of Tolimit Gauges in connection with the transfer was that Belfast is closer than their present works to the company's northern customers and by maintaining a sales office in London it should be possible to improve the service to customers.

The I.C.I. project, though it will take longer to mature is, of course, considerably larger. It is hoped that it will be possible to start production by 1963-64 and when full production is achieved a labour force of 1,150 will be required. Subsequent expansion may raise this figure to 2,000. In the meantime considerable employment will be afforded in building the factory.

In December, 1957, the number of unemployed in Northern Ireland was 36,246, representing 7·6 per cent of the insured population as compared with 1·7 per cent for the United Kingdom as a whole. Unemployed men totalling 27,062 represent a higher proportion of the total than in most other areas of the country. For this reason the Northern Ireland Government offer more favourable terms to those industries which employ mainly men. In recent months declining employment in the established industries has more than outweighed the increase due to the establishment of new factories, with the result that unemployment has risen to more than 9 per cent. The full effect of the establishment of new industries cannot be felt immediately but some improvement in the position should occur in the next two years.

Hazard on the Seas

The disastrous fall in merchant shipping freight rates in the past few months is causing anxiety to British owners. The chairman of Orient Steam Navigation Company Limited, Sir Austin I. Anderson, spoke in his annual report of "a difficult and arduous year" during which the Suez crisis had a most adverse effect on his company's profits. The closing of the Canal resulted in a sharp increase in the prices of oil bunkers and various other rises in costs—including a further increase in the National Maritime Board rates of sea pay, and higher repair charges causing running costs for 1957 to be 8 per cent higher than those for 1956. Orient Steam Navigation are heavily dependent on the Suez route and lost at least £500,000 through the closure of the canal and the discouraging effect this had on the passenger traffic from Australia and the Middle East.

Commenting on the fall in freight rates which followed the Suez crisis, Sir Austin Anderson said that his company "would be the last to deny the healthy effect of 'free for all' competition or that it can temporarily produce 'cut-throat' rates which are attractive to those who take advantage of them." However, the uncertainty of getting return freights prevents efficient long term planning and "redundant tonnage is an extravagance that must eventually be paid for." Despite the severity of the present conditions, Sir Austin was confident that the prospects for his company remained very good, and that traffic would greatly increase on the Suez and Pacific routes used by their ships. Similarly, the fact that the tanker market is at present so depressed does not change the view he held two years ago about the desirability of his company widening their interests by acquiring tankers, the first of which is now under construction.

The problem of fluctuating freight rates is actively being tackled by the United Kingdom Chamber of Shipping. They have been discussing the possibility of united action, such as a controlled lay-up of tonnage, to counteract the fall in freights. The Tonnage Stabilisation Scheme created in 1951 under the auspices of the Chamber is still in existence. In view of the growth of "flag of convenience" fleets, however, and the declining importance in the world fleet of United Kingdom tramp tonnage, such a scheme would need international support to have any chance of success. United Kingdom tramp shipowners may therefore try to obtain support from the other traditional maritime nations next month. Something of the kind is certainly required, but any international agreement, which must include fleets operating under tax-free conditions, is likely to prove difficult.

Atomic Review

Physical Aids

BETWEEN nuclear engineering and the rest of industry there is a two-way commerce. The development of nuclear energy has spawned a wealth of new techniques, processes and tools, while calling in return for special materials, instruments and engineering services. The Physical Society Exhibition (24-27 March) illustrates this intercourse, showing, for example, nuclear devices for testing and checking materials, and novel materials developed for reactor fuel cans.

Materials and Fin Tube

On the stand of Accles and Pollock Limited, examples were shown of the results of tube research and development—largely concerned with special metals and new tube fabrication processes. Development work is still proceeding in the manufacture of tubing in unusual materials which, in many cases, are needed for both reactor construction and the attendant chemical processes in atomic energy plants. Many examples of the finned sections for the canning of uranium were exhibited (Fig. 1). Materials include aluminium, magnesium-aluminium alloy and niobium.

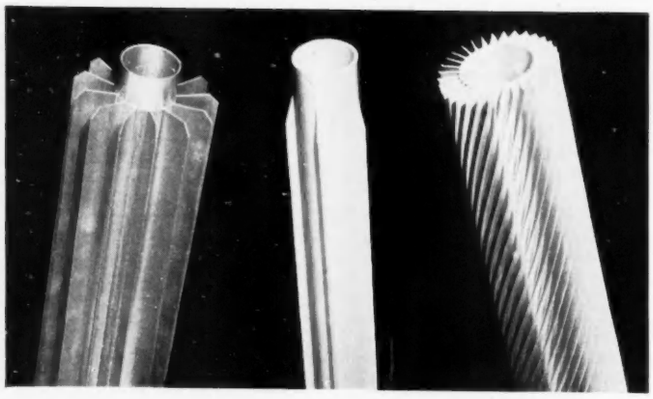


Fig. 1 (above) Varieties of extended surface for canning nuclear fuels.

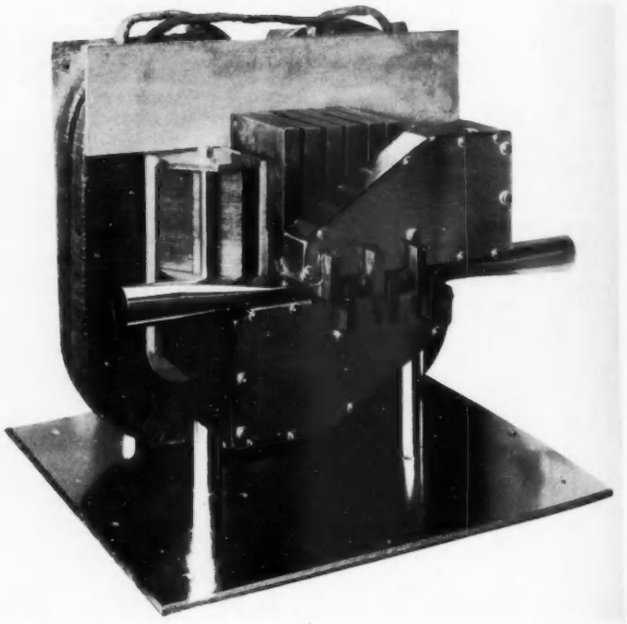


Fig. 2 (right) Single-phase conduction pump for liquid metals.

Low-hafnium zirconium was shown. The material captures few thermal neutrons, has fairly good resistance to corrosion, but has poor mechanical properties at high temperature. The addition of tin and small quantities of iron, chromium and nickel, has resulted in an alloy named Zircaloy 2. This has improved mechanical properties and resistance to corrosion in high-temperature water. The company say it is of great importance for those power reactors using high-pressure high-temperature water as a moderator and coolant.

Also shown was beryllium, which has an extremely low capture cross-section for thermal neutrons, excellent moderating properties and good corrosion resistance to gases. It is thus a most desirable nuclear material. Unfortunately, it is anisotropic, lacks ductability and is brittle. These properties complicate manufacture and utilisation. The firm cannot supply tubing in this material at the moment as further development work already in hand is necessary to overcome the problems of manufacture.

Other materials shown included tantalum—which has a melting point of 2,296°C combined with strength at high temperatures and resistance to most corrosive liquids—vanadium, molybdenum, and niobium. The last three have melting points of 1,880°C, 2,620°C and 2,415°C, and have similar properties to tantalum. Their ability to withstand uranium to temperatures above 1,000°C and to resist the corrosive effects of coolants such as liquid sodium make their use attractive for enriched reactor systems. Niobium is of particular value for use as a canning material for uranium in nuclear reactors. Molybdenum is still in an early development stage and considerable work is still necessary to overcome problems of manufacture in tube form. Development work is still proceeding in the manufacture of seam-welded tubes in commercial purity titanium and seamless tubes in titanium alloys. The firm can supply seamless tubes up to 1¼ in by 12 s.w.g. in commercially pure titanium.

The Atomic Weapons Research Establishment, Aldermaston, showed some equipment used for the deposition of nickel by thermal de-composition of nickel carbonyl. A description of this technique is given on page 401 of this issue. The equipment on show used low chamber pressures, though provision was made for pressures up to 100 mm. Electro-magnetic pumps—they circulate a conducting liquid by electromagnetic forces developed directly within the liquid—were displayed by the British Thomson-Houston Company, Limited. A 20 gal/min 20 lb/sq. in single phase a.c. pump is shown in Fig. 2. By use of the proper tube materials it can handle mercury and bismuth or sodium and sodium potassium alloys.

Radiation and Electronics

Ecko Electronics Limited showed a gamma back-scatter gauge. The instrument, type N563, is designed for the measurement of steel thickness where only one side of the sample to be measured is available; it was demonstrated measuring wall thicknesses of steel pipes. The principle of operation is that when gamma rays pass through steel a proportion will be deflected by Crompton scattering. Some will be scattered through 180°; during this process they will loose energy at twice the Compton wavelength. If cobalt 60 is used as a source, back-scatter radiation will return at about 200 keV. The unit has a built-in e.h.t. supply for the photo-multiplier tube and suitable time constants to remove random fluctuations on the indicating meter. Transistors in association with printed circuits are used in the equipment; the model shown was for battery operation, but for permanent installations a mains operated power unit is available. The useful range of the instrument is up to 1 inch thickness, in steel.

Many pulse analysis and counting devices were shown at the exhibition.

Labgear Limited showed their directional scintillation counter, type D4133. This unit is primarily intended for medical applications using low level gamma radiation where the sensitivity is required to be confined to a comparatively narrow beam. The counter comprises essentially an 11 stage photo-multiplier having a 1 in diameter cathode associated with an encapsulated sodium iodide crystal and a suitably shaped lead shield, which collimates the radiation over a small solid angle. The lead cap makes provision for the fitting of collimating inserts giving three different polar characteristics. One provides a cone-shaped aperture to confine detection at a range of 12 in to a flat field 5 in in diameter, which will restrict radiation within 20° of its axis, to the virtual seclusion of the surrounding radiation. The second, utilising a straight sided hole gives a much finer resolution and a response angle of less than 10° covering a circle of 1¼ in in diameter at a range of 12 in. A third provides both directional and depth characteristics by the use of six equi-spaced tapered holes inclined so that their axes converge at a point 2 in from the nose of the unit. These variants cover the directional characteristics required in such applications as cardiac output determination, thyroid uptake studies, and other routine organ or body scanning techniques.

A beta-ray source was used in a device, shown by the National Institute of Medical Research, for the detection of low concentrations of the vapours of organic substances. The rapid development of gas chromatography as a method for the analysis of complex mixtures of organic substances has greatly increased the need for sensitive devices to detect and measure the low concentrations of vapours emerging from the chromatograph columns. A simple and sensitive device for this purpose is based on the special ionisation properties of the rare gases. Irradiation produces in the rare gases relatively high concentrations of metastable atoms and these, on collision with organic vapour molecules, produce ions. The practical detector based on this property of the rare gases consists simply of an ionisation chamber containing a source of beta radiation. The chamber is attached to the end of a gas chromatograph column through which argon is flowing. The emergence of the separated organic vapours is indicated in the current flowing in the ionisation chamber. Such an instrument will detect organic vapours at concentrations at least as low as 1 part in 10^{10} by volume. It is also relatively insensitive to temperature, pressure, and flow-rate changes.

An irradiation applicator for the eye was shown by the National Research Development Corporation. In radiation therapy particularly

for the eye, a practice has been to use an individually made applicator similar to a contact lens, with a recess in its outer surface specially placed according to the area to be irradiated. A radioactive disc, suitably shielded to prevent unwanted irradiation is inserted in the recess. The disadvantages of this *ad hoc* applicator method are overcome in the device shown, which consists broadly of one of a small number of standard applicator shells which will accommodate a great number of eyes without the necessity of close fitting. The outer surface of the shell is recessed over a substantial area to receive a concave carrier disc, which in turn has an eccentrically placed recess to receive one of a number of standard plates containing an eccentrically positioned radioactive lamina. By rotation of the carrier in the shell and the plate in the carrier, the radioactive lamina can be placed opposite to any part of the eye requiring to be irradiated. It has been found that with two or three standard applicators the needs of most eyes can be met.

Vacuum Pumps

An ultra-high-vacuum pumping system was shown by Edwards High Vacuum Limited. The following items were displayed:

(1) An all metal shut-off valve with a closed conductance of the order of 10^{-10} litres per sec, which can be baked to 450° C.

(2) An ionisation gauge measuring pressures down to 10^{-10} mm of mercury, which can be baked to 450° C; the electrodes can be heated to 1,000° C by electron bombardment. The power supply unit supplies four ranges of stabilised grid current from 10 to 0·01 mA. Intermittent operation at 10 mA permits very low pressure measurements using a relatively insensitive amplifier and avoiding continuous pumping of the gauge.

(3) A sensitive d.c. amplifier with an electrometer valve as the first amplification stage. Ionisation currents can be measured down to 10^{-13} A corresponding to a pressure of 5×10^{-11} mm Hg.

(4) A simpler seven-range d.c. amplifier which measures down to $2{\cdot}5 \times 10^{-11}$ A, corresponding to a pressure of $1{\cdot}25 \times 10^{-10}$ mm Hg.

A 3 in oil diffusion pump designed to give improved speeds at high through-puts was exhibited by Metropolitan-Vickers Electrical Company Limited. An aluminium alloy fractionating jet system incorporating a third stage ejector jet in the backing line is used. The pump has an unbaffled pumping speed of 120 litres per sec and a critical backing pressure of 400 microns. The ultimate pressure at 15° C is 1×10^{-6} mm Hg, using Apiezon oil B. A plate type heater and radiation shield are fitted.

G.E.C. Power Manipulator

The G.E.C. power manipulator, illustrated in Fig. 3, the first general-purpose power-operated manipulator to be designed and produced in Europe, has been developed to provide remote-handling facilities in any situation where it is impossible, or undesirable, to employ a human operator, and where objects too heavy for conventional manipulators have to be handled. While the basic design was produced in the G.E.C. Atomic Energy Division at Erith, mainly with a view to its use in the nuclear-energy field where toxic and radioactive materials must frequently be handled, it is equally applicable, for example, in certain chemical plants where poisonous atmospheres or hazardous processes are involved. The power manipulator is the mechanical equivalent of a human arm and hand, although it is, in some ways, capable of a greater range of movements than its human counterpart; in addition, it can carry heavier loads and can maintain a given position over long periods. To quote but a few examples of the machine's versatility, it can lift and accurately position objects weighing as much as 750 lb, handle delicate glassware without breakage, pour and stir liquids, and wield a large variety of hand and power-operated tools.

The complete operation of the manipulator is controlled by one person from a small console which is readily movable and can be conveniently located according to the viewing arrangements. Unlike the hand-operated manipulators commonly used for light handling duties, there is no mechanical linkage between the machine and the console, the only connections consisting of multicore electric cable. There is, therefore, no limitation on the distance between the power manipulator and the operator as long as some means of remote viewing, such as closed-circuit television, is available.

Mechanical Construction.—The manipulator consists of a grasping device carried on a wrist, capable of continuous rotation, which is supported from a forearm, upper arm and shoulder. The arm joints are designed so that each section can rotate through 180° about its pivot, while the shoulder joint can rotate continuously about a vertical axis. The shoulder is mounted in the base of a set of vertical telescopic tubes, the upper section of which is rigidly fixed to a crane-type carriage. This carriage can be traversed across a gantry spanning the working area and travelling on longitudinal rails mounted near the top of the walls of the cell. The gantry also supports a 1½ ton electric hoist with a cross-traverse parallel to that of the manipulator carriage.

The telescopic tubes, which are housed in the carriage when in their stowed position, have a positive raise and lower action, the sliding movement between tubes being taken on anti-friction bearings running on stainless-steel paths. The driving motor for the tubes is mounted in the carriage.

The lowest tube houses three drive units, one for shoulder rotation, one for the shoulder pivot by which the upper arm is moved, and one for the elbow pivot which controls the movement of the lower arm. The drives to the two pivots are transmitted through sets of gears mounted in the shoulder casting, followed, in the case of the elbow pivot, by a train of spur gears inside the upper arm. A 20 way slip-ring column, through which the electrical connections to the rotating section of the manipulator are made, is also housed in the lowest telescopic tube.

Mounted on the lower arm are two drive units, one for the wrist which gives continuous rotation in either direction, and the other for the grasping device. Two such devices are normally supplied. The more versatile of these takes the form of a hand with two jaws capable of a maximum opening of 5 in and of applying a grip force of any value up to 150 lb. The jaws are opened and closed by means of a parallelogram linkage driven by a rack which, in turn, is coupled to the drive unit by a differential gear. The torque on the arm of this gear is used to provide an indication of the grip-pressure applied by the jaws, a spring deflected by movement of the arm being arranged to actuate a transducer. The alternative device, which is mainly used for lifting duties, comprises a hook which can be driven against an anvil. The same drive unit is used for both the hook and the hand.

The grasping devices can be interchanged remotely. The device already attached to the manipulator is driven into a fixture which grips it firmly and, at the same time, releases a locking ring on the wrist. The wrist is then rotated until the device frees itself. The other device, which is housed in another fixture, can then be attached to the manipulator by carrying out the reverse process.

Control.—All the movements of the manipulator are controlled by means of two joysticks mounted in the front face of a console. The joystick handles have simultaneous freedom of motion in four directions, each direction being associated with a corresponding movement of one of the manipulator components. The degree of displacement of the joystick is proportional to the speed of the corresponding manipulator movement. The motions of the joysticks are arranged to follow logically those of the manipulator so that a relatively unpractised operator can control the machine with ease. The control for the hand or hook has been designed so as to permit adjustment of both the closing speed and the grip force. These two features are incorporated in one joystick motion so that low grip-force is associated with low speed, since a high speed of closing on to a delicate object is not a natural requirement.

The outward thrust or grip-force between the hand jaws is indicated on an instrument mounted on top of the console. This instrument is non-linearly scaled 0 to 150 lb so that the 15 lb graduation is in the midscale position, thus ensuring adequate sensitivity of indication when handling light or fragile objects. A further indication of grip-force is provided in the form of an audible signal from a variable-frequency oscillator so that the operator can, when necessary, concentrate on watching the manipulator. Switches for controlling the hoist block and for locking any of the manipulator motions in a given position are provided on the top of the console.

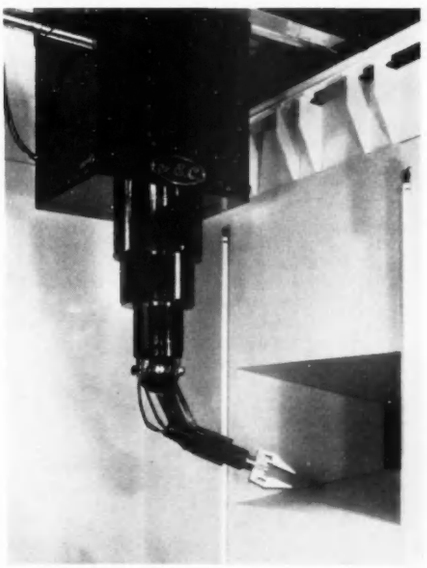


Fig. 3 G.E.C. power manipulator for remote handling of radioactive or toxic materials, particularly when the articles to be handled are heavy. Operation is electrical.

Fig. 4 Operating console of the G.E.C. power manipulator. Two hand-operated joysticks provide a wide range of motions. Objects weighing up to 750 lb can be handled.

Notes and News

Next Steps in the Nuclear Programme

"The Further Development of the U.K. Nuclear Power Programme" was the subject of the James Forrest Lecture for 1958, delivered at the Institution of Civil Engineers on 18 March by Sir John Cockcroft. Sections of the paper are summarised in the following notes.

Increased Output

As stated in Atomic Review last week, nuclear power stations little larger than Calder Works can now be built having many times the output. Even the first stations now under construction for the Central Electricity Generating Board have capacities more than twice as great. The increase in output has been achieved by straightforward engineering development. First by an

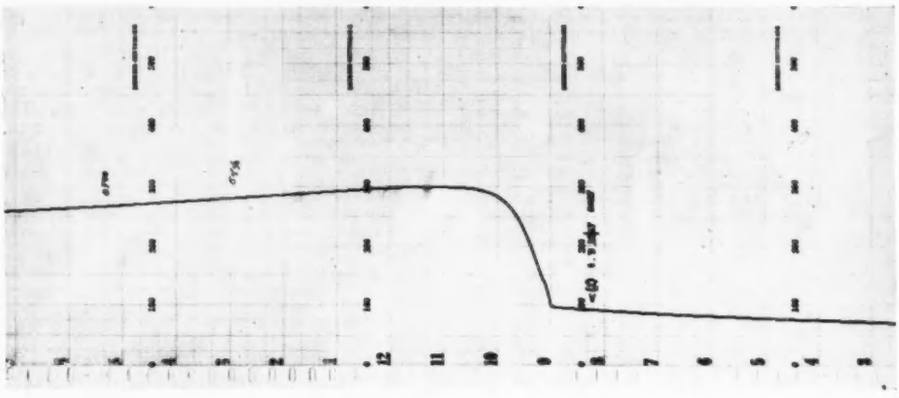


Fig. 5 Temperature of graphite plotted against time during the Wigner release recently carried out on BEPO at Harwell.

increase in the size of the reactor and a corresponding increase in the amount of uranium fuel. Second by an approximate doubling of the amount of heat extracted from each ton of uranium. This increase in rating has been achieved by increasing the fuel element surface temperature from 410° C to about 425° C; by a 50 per cent increase of the pressure of the carbon dioxide heat-transfer gas and by improvements to the heat transfer surface. The overall result of this progressive increase has been to decrease capital costs per kilowatt.

Fuel-Element Life

The Electricity Board reactors will operate the fuel elements at higher temperatures than at Calder Hall. The fuel-element life is expected to be dominated by the internal pressure exerted by fission gases. These collect in small bubbles in which pressures of several hundred atmospheres may build up. At temperatures of 450° C to 600° C, uranium is fairly plastic and the internal pressure causes a volume expansion which may be of the order of 10 per cent at 3,000 MW days per ton exposure, the actual amount depending on metallurgical imperfections, such as inclusions, creep strength and other factors. The magnox can is therefore being designed to accommodate such expansions. An extensive programme of testing fuel elements for the civil reactors is envisaged in the Calder reactors.

Two Lines of Advance

Though pressurised and boiling water reactors had advantages where enriched fuels were abundant, for Europe they were less promising, Sir John considered. The sodium-graphite system too had overriding disadvantages. (A full discussion of the pressurised-water and sodium-graphite systems appeared in ENGNG., vol. 182, p. 727, '56.) The United Kingdom Atomic Energy Authority were therefore concentrating on two future lines of advance: first, the development of the gas-cooled graphite-moderated reactor to the maximum of its considerable potentialities; and second, a possible change to heavy water as moderator. The ultimate development of the gas-cooled system was the high-temperature gas-cooled reactor (see ENGNG., vol. 182, p. 725, '56, and Atomic Review, 10 Jan., and 7 and 21 March '58). There was a further system, the fast fission reactor, such as that nearing completion at Dounreay, but its urgency had largely disappeared, since uranium was now available in plenty (30,000 tons a year in the West) and certainly sufficient to support any foreseeable nuclear programme up to 1970. It might, however, prove the best way of burning the plutonium produced in thermal reactors, though it is unlikely to play a major part before the 1970's.

Advanced Gas-Cooled Reactor (AGR)

A project promising well is the advanced gas-cooled reactor (AGR). The objective of the AGR is to decrease capital costs per kW by a substantial amount—of the order of 30 per cent—by increasing the surface temperature of fuel elements to about 600° C. By this means and by using clusters of smaller-diameter fuel elements, average ratings should be increased to the region of 8 MW (thermal) per ton. To enable this increase of fuel-element temperature to be obtained uranium metal fuel will be replaced by a sintered uranium-oxide (UO_2) fuel element. Sintered uranium-oxide has a melting point of about 2,400° C. This type of fuel is already being used in the Westinghouse PWR reactor and has been shown to have very good irradiation stability, and burn-ups of up to 8,000 MW days per ton have been achieved. The uranium-oxide fuel elements would probably be sheathed in beryllium. Beryllium cans have already been fabricated and sealed; specimen fuel elements have undergone hundreds of thermal cycles through the $\alpha\beta$ change point without damage. A first specimen load is now going into DIDO to determine overall irradiation stability. Experiments with a zero-energy reactor, NERO (see Atomic Review 15 March '57), are also being carried out to study the nuclear properties of the AGR.

AGR Costs

Something would have to be paid for the high ratings and the use of uranium-oxide, and the proportion of uranium 235 will have to be increased slightly. To set off against the higher fuel element costs, the greater irradiation stability and higher efficiency ought to give about twice the amount of heat per ton. It is believed therefore, that overall fuel costs will be about the same as the first generation reactors—about 0·16 pence per kWh. Because of the high ratings however, capital costs of the order of £80 per kW ought to be achieved so that with the load factors of the order of 70 per cent predicted for the late 1960's overall costs should come down towards the 0·47 pence per unit prophesied by Sir Christopher Hinton for 1970.

Heavy-Water Moderated Gas-Cooled Reactor

A promising alternative reactor to the AGR is the heavy-water moderated gas-cooled reactor (see Atomic Review, 4 Oct. '57 and 17 Jan. '58). This reactor has the potential advantage of a smaller reactor size than the graphite-moderated reactor, leading to lower capital costs and it ought to be possible to achieve £80 per kW in large outputs (500 MW electrical). Fuel ratings would be similar to those of the advanced gas-cooled reactor while, because of the favourable neutron economy of heavy-water reactors, only a slight enrichment would be required and fuel costs would be lower than for the AGR. The use of a liquid moderator avoids stored energy and oxidation problems, and the fact that the moderator is kept cool reduces reactivity temperature coefficient problems.

Substantial quantities of heavy water would be required and this would contribute between £10 and £15 per kW to the capital cost of £80 per kW. Heavy water is available at present in the United States at about £20,000 per ton. Technological work on heavy-water production has been carried out at Harwell during the last few years and it is believed that it would be possible to produce it at comparable prices in the United Kingdom and other European countries. The overall economics of the heavy-water gas-cooled reactor should therefore be as favourable as the AGR.

Trends in Fuel Costs and Consumption

Sir Christopher Hinton, delivering the Trueman Wood Lecture at the Royal Society of Arts last week, stated that " if development of nuclear power stations can be continued at its present

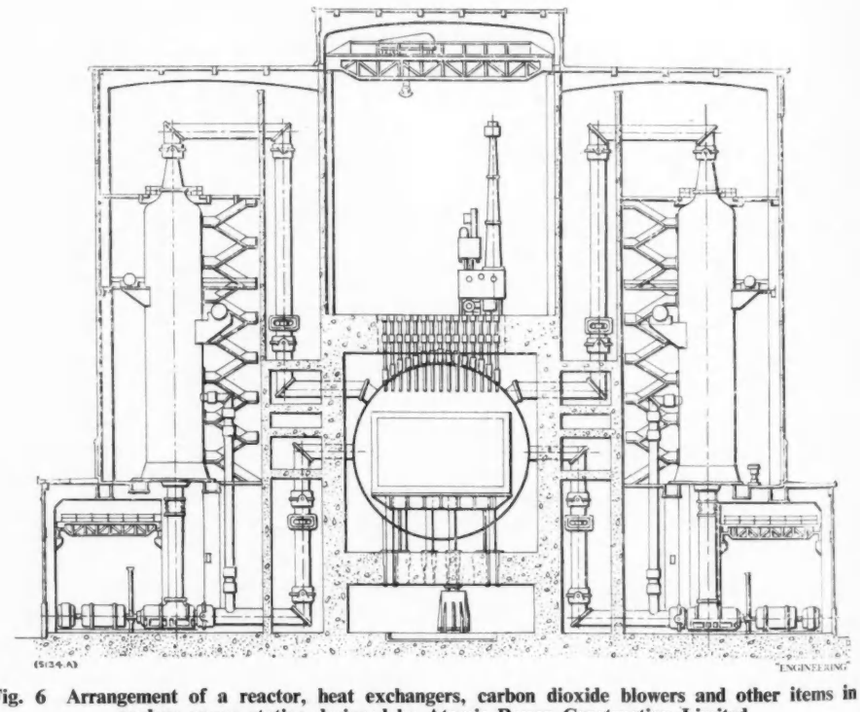


Fig. 6 Arrangement of a reactor, heat exchangers, carbon dioxide blowers and other items in a nuclear power station designed by Atomic Power Construction Limited.

pace and if the present trend in coal costs continues, nuclear power will be cheaper than power from conventional stations by 1962, and that by 1982 it will amount to less than half the cost." In consequence there might, he said, be a change in practice in domestic heating; coal would be less commonly used for this purpose. Coal would then find increasing application as a raw material for the chemical industry; perhaps we were wrong to burn it as a fuel.

Wigner Release in BEPO

Further details of the experimental Wigner release carried out in BEPO and referred to in Atomic Review last week have now been made available. Beginning at 9 a.m. on 15 March, the operation lasted until 11.30 a.m. on 16 March, when the temperature in all parts of the reactor was falling rapidly. Heat was supplied to initiate the release, not by nuclear means, but by controlled electrical heating of the intake air at a maximum rate of about 750 kW. A total of 411 thermocouples were employed to record the temperatures throughout the reactor, and of these 232 were dispersed among the graphite blocks, 65 recorded fuel-element temperature, and others were ready for connection to recorders when required. After 10 hours, the temperature had been raised slowly to about 90° C; at 1.40 a.m. on 16 March the first local rise in temperature occurred and continued at intervals through the small hours. The highest temperature reached was 330° C and individual blocks of graphite rose in temperature by as much as 200° C in about 5 minutes. The speed of these local rises was very striking. Along a fuel channel the zone of energy release spread slowly from the air inlet end to the exit and also outward from the fuel channel. The reactor could have been blown cold at any time using the main circulating fans. Fig. 5 is a graph showing graphite temperature plotted against time for one point in the reactor. An article by Dr. P. J. Grant, of the G.E.C. Atomic Energy Department, discussing Wigner effect in detail was published in ENGNG, 24 Jan. '58, p. 120.

Progress at Bradwell

A visit to the Bradwell nuclear power station site to mark the occasion of the commissioning of the Goliath crane, provided an opportunity to see the good progress that is being made with this project by the Nuclear Power Plant Company Limited.

The erection of the main biological concrete shielding at each of the two reactor sites is now well under way as are also the foundations for the heavy boilers. The 200 ton boiler shells, twelve in all, will be floated down the North Sea from the factory of Head, Wrightson and Company Limited, to Bradwell, and the 1,200 ft track for the Goliath crane will enable them to be lifted almost from the jetty and hoisted into position. Further details about this crane will be given next week, p. 439.

A.P.C. Reactor

The formation and membership of Atomic Power Construction Limited has already been mentioned in Atomic Review (28 Dec. '56, 31 May and 29 Nov. '57). In the latest issue of *The Link*, the house magazine of the Richardsons Westgarth Group, the activities of A.P.C. are outlined, which include studies of beryllium, zirconium, niobium, stainless steel, graphite and ceramic fuels. Nuclear propulsion for merchant ships is also being considered. The arrangement of a proposed reactor plant, designed by A.P.C., is shown in Fig. 6.

Postgraduate Course in Nuclear Power

The postgraduate course in nuclear power at the Imperial College of Science and Technology was started in 1957 under Professor J. M. Kay. A booklet has now been published giving full details of the course, which includes studies using a sub-critical natural-uranium graphite assembly. The fee for the course, which is fully described in an article by Professor Kay on page 394 of this issue, is £64. Inquiries should be made to the Registrar, Prince Consort Road, London, S.W.7.

Submarine Project Appointment

It has been reported that Mr. Rowland Baker has been appointed technical chief executive in the nuclear submarine project for the Royal Navy.

U.S.A.E.C. Report

The twenty-second semi-annual report of the United States Atomic Energy Commission has recently been published and comprises a three-year summary of work entitled *Progress in Peaceful Uses of Atomic Energy*.

Subterranean Nuclear Explosion: Peaceful Uses

A nuclear device designated Rainier, was detonated deep underground last September at the Nevada Test Site, U.S.A. The shot, with a known yield of 1·7 kilotons, and designed by the Los Alamos Scientific Laboratory, was placed in a chamber 6 ft by 6 ft by 7 ft at the end of a tunnel approximately 1,900 ft long that had been bored horizontally into the side of a tufa (volcanic) rock mesa near the northwest corner of the site. The shot chamber was about 900 ft under the mesa top, and about 800 ft from the steeply sloping hillside. The tunnel, of hook shape, was as indicated in Fig. 7. Arising out of suggestions by Dr. Edward Teller of the University of California Radiation Laboratory and of David Griggs of the University of California at Los Angeles, the project was planned and conducted by the Livermore Branch of the UCRL. A self-sealing tunnel was designed, in which the shock from the explosion would close with rock a portion of the tunnel before the air shock wave, travelling through the tunnel, reached the sealed off portion. One main tunnel and two subsidiary tunnels were driven by the main contractors, E.C. Nickel Construction Company, using Atlas Copco BBC22 pusher-leg mounted rock drills with Sandvic Coromant drill steels.

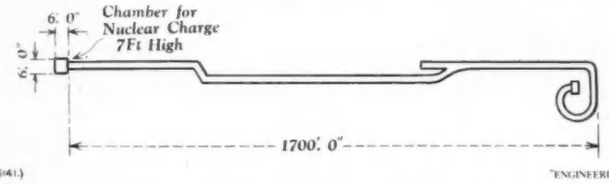


Fig. 7. Design of the main tunnel for the Rainier subterranean nuclear explosion carried out last September. The hook design ensured that fission gases and particles could not escape.

A number of operational benefits were expected to be derived from deep underground detonations of nuclear devices. Among these were: (*a*) total absence of fallout; (*b*) the absence of blast and flash effects on off-site residents and travellers; and (*c*) elimination of radioactive clouds which interrupt and interfere with air traffic. The Livermore Branch of the University of California Radiation Laboratory is now engaged in Project Plowshare, an investigation into the possible application of nuclear detonations for peaceful purposes. Considerable information that will be of interest in Project Plowshare was obtained from the Rainier detonation and the studies that have followed it. For example, it has been calculated that the underground shot produced at least 50,000 tons of permeable broken rock and an additional 400,000 tons of crushed, but relatively impermeable rock. The large masses of broken rock suggest such applications as occur in mining to break up ore bodies for removal or leaching, and in oil strata to free crude oil trapped in relatively non-porous rock formations. It is also considered possible that heat resulting from an underground detonation in oil strata might increase the production of oil in certain situations by making it flow more freely through the rock formation. Other possible peacetime applications include: (1) piping water into a rock formation heated by a contained nuclear detonation to form steam for producing power or for other uses; (2) placing various materials around a device to be detonated deep underground so as to effect changes in the materials through nuclear reaction; (3) further investigations of the make-up of the earth's crust through seismic studies of earth waves resulting from deep underground detonations; and (4) moving earth in quantity.

Nuclear Rocket and Ram-jet Propulsion

Programmes of research into the application of nuclear propulsion to atmospheric and space vehicles have been assigned to the Los Alamos Scientific Laboratory and the University of California Research Laboratory, Livermore. The Nevada Test Site has been selected for experimental purposes. Project Rover (LASL) is concerned with rocket propulsion and Project Pluto (UCRL) with ram-jet systems, which are confined of course to the earth's atmosphere. First field tests of reactor systems are scheduled for late this year. Mr. Lewis L. Strauss, chairman of the U.S.A.E.C., has said that flight tests of rockets propelled by nuclear systems are probably somewhat more distant than the next two or three years. The high-temperature gas-cooled reactor is being considered as a heat source for ram-jets. Nuclear powered rockets and ram-jets were discussed in Atomic Review last 28 February.

Materials Reactor at Saclay

Pile EL3 at the Centre D'Etudes Nucleaires, Saclay, France, reached a power of 10 MW on 8 March. The pile is for materials research; the maximum neutron flux obtained was greater than 8×10^{13} neutrons per sq cm per sec. EL3 started at low power on the 4 July 1957 and reached 3 MW in December. The pile now produces a neutron flux ten times that of its predecessor EL2, and allows work on materials and radioisotopes to proceed more rapidly. EL3, say the Commissariat a L'Energie Atomique, can now be numbered among the major research reactors in the world—the third most powerful, after MTR in the United States and DIDO in Britain, not counting Russian reactors.

Nuclear Research Laboratory

C. A. Parsons and Company, Limited, propose to build at the Fossway, Newcastle, a laboratory for atomic power station problems.

Novel Reactor Propulsion Unit

Last week Mr. F. J. Mitchell stated that his company, Mitchell Engineering, Limited, had developed a revolutionary nuclear power plant, especially suitable for marine propulsion. The reactor core, it appeared, would be coupled directly to the drive shaft and would rotate with it. Steam was the working fluid. The principle involved was not disclosed but risky speculation leads to the supposition that the reactor core contains helical coolant channels through which the steam passes, being heated at the same time. The device would then be a cross between a ram-jet and a turbine. £100,000 had been set aside for the project and a patent applied for.

Pumped Storage in Wales

The pumped storage scheme at Blaenau Ffestiniog is to be connected directly with the grid and will operate independently of any nuclear power station that may be built in the area. The decision of the Minister of Power as to whether a nuclear power station of between 400 and 500 MW may be built on the edge of the Trawsfynydd reservoir is expected after Easter. Reference to the two schemes first appeared in Atomic Review 5 April '57.

Planning Power Developments

A discussion of the present condition of the electric power industry with special reference to atomic energy appears in the Leader on page 385.

Metals and Materials

MATERIALS AT THE PHYSICAL SOCIETY EXHIBITION

Although the Physical Society Exhibition is chiefly concerned with instruments a proportion of the firms display materials—usually new types for use with experimental equipment.

At the recent exhibition (24-27 March) Johnson Matthey and Company, Limited, displayed their machinable tungsten-base alloy, Mallory 1000. The material has a specific gravity of 16·9. It is extensively used for such purposes as counter-balance weights in aircraft controls, instrument balance weights and gyroscope rotors. By comparison with lead it offers advantages of 50 per cent higher density, superior heat resistance, greater mechanical strength and the ability to be machined readily to close limits. As would be expected from a material of such density it effectively absorbs gamma radiation. It is thus very useful for radiation screening applications.

On the same stand platinum-alloy permanent magnets were shown. Alloys in the cobalt platinum system show interesting ferromagnetic properties, especially the alloy containing 23·3 per cent by weight of cobalt. This particular alloy after heat treatment gives values of BH (maximum) as high as $9{\cdot}0 \times 10^6$ and a coercive force of 10,000 oersteds. Unlike base metal alloys which are used in the cast condition, cobalt platinum is extremely ductile before heat treatment and so lends itself to the manufacture of parts the production of which would be impracticable with base alloys.

Accles and Pollock Limited exhibited their range of helically-gilled tubing developed for high efficiency heat exchangers. Surface area ratios in excess of $3\frac{1}{2}$: 1 have been obtained in mild steel. (The ratio referred to is that between outside surfaces of a cold tube and a plain tube of diameter equal to that of the gill root.) Development work is still proceeding with this type of tubing, and with the installation of new equipment the company are hoping to produce the following: (*a*) up to 6 in crest diameter, (*b*) surface area ratios up to 6 : 1, (*c*) up to 20 ft long. Most of this work has been confined to mild steel, but trial batches in stainless steel, aluminium and magnesium alloys have been successfully produced. Samples in zirconium and titanium were included in the exhibits. The company is now experimenting in the production of composite extended surface tubes the bond being either mechanical or metallurgical.

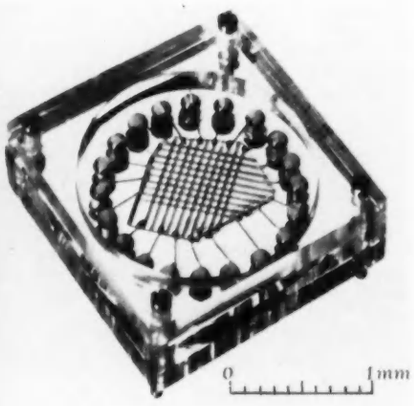
The company say they are also proceeding with development work on a 500 ton hydraulic press, which has been installed for the extrusion of tubes and solids in both round and section form, in various alloys. They have tended to concentrate on special longitudinal finned tubing in such materials as pure aluminium, aluminium alloys and magnesium alloys. These are required for the canning of uranium in nuclear reactors.

Also shown were tubular electrodes for cathode ray tubes. Tubes plain or manipulated in non-magnetic stainless steel (permeability less than 1·1) are supplied for accelerator and focus anodes in the electrode assembly in cathode ray tubes. These must be dimensionally accurate and have a very smooth and clean finish, particularly in the bore. Tubes for this application have also been supplied for materials such as Nichrome 5, cupro-nickel and Brightray S. Experiments are proceeding with equipment to improve the smoothness of surface finish particularly for tubes for use as focus anodes in electrostatic types of cathode ray tube.

Examples of dishes and crucible forms in tungsten by spinning were shown by Murex Limited. Molybdenum spinnings in large dimensions are also available and large molybdenum rods for furnace electrodes are being produced. An example of the fabrication of molybdenum and tungsten was shown in the form of an element for a heating unit for temperatures up to 1,800° C. Tungsten rods formed the heating elements and molybdenum plates the radiation shields.

A silicon crystal puller was exhibited by the Services Electronics Research Laboratory, Baldock. Of advanced design, the puller permits production in high vacuum or inert gases of single-crystal silicon by the Czochralski method. A large quartz window gives almost perfect vision throughout the pull and all material may be withdrawn from the crucible. The puller is provided with a large door so that the accurately placed heater and radiation shields may be removed and replaced quickly with little change in thermal conditions. Provision for raising and lowering the crucible in the heater, as well as crucible and seed rotation, is provided. Development has progressed to the stage where the major part of the pulling is by programme.

The Plessey Company Limited have been proceeding with the development of intermetallic semi-conductors. Indium antimonide and indium arsenide crystals were shown. Both materials have applications as infra-red detectors and as Hall and magneto resistance probes. The Plessey infra-red cell, type P.C.21, which utilises the photoelectromagnetic effect in a single crystal



The silicon solar generator has a *p-n* junction close to its surface. About 0·5 V is produced.

filament of indium antimonide, was shown and demonstrated in the operation. The company also exhibited a solar generator. It consisted of a *p-n* junction formed within 0·000 5 in of the surface of a slice of low-resistivity single-crystal silicon. Under the influence of light, minority carriers diffuse to the junction and so generate a current. The e.m.f. is about 0·5V and the efficiency is 5–10 per cent. The device is made possible by the existence of charge carriers of both signs within the semiconductor; a carrier pair is produced by the absorption of a photon.

Indium arsenide was also displayed by Metropolitan-Vickers Electrical Company Limited. The semi-conductor has an exceptionally high mobility (30,000 cm^2/Vs), exceeded only by that of indium antimonide. It has a Hall coefficiency practically invariable up to a temperature of 100° C. These two facts make it particularly suitable for application to devices based on Hall effect or magneto resistance effect. Some devices of this kind such as flux meters, transducers and electrical multipliers are described in the company's literature. A double sideband suppressed carrier modulator was demonstrated.

The Admiralty Signal and Radar Establishment showed materials suitable for matched terminations at microwave frequencies. Glass fibre cloth impregnated with colloidal graphite has been found suitable for experimental medium power matched terminations. The surface resistivity of this material can be altered in wide limits. Over 100 dB/m absorption is obtained when inside walls of X-band waveguides are lined with this cloth. Rapid cooling through the waveguide walls permits comparatively high microwave power dissipation density. This cloth can also be used for absorption of h.f. energy propagating along the metal surfaces of supporting structures. Silicon-silicon carbide refractive materials have been found suitable for high power dry matched termination. Their h.f. resistivity can be altered in wide limits to suit particular applications. The density of h.f. power dissipation can be very high as the material can be run permanently at very high temperatures (up to 1,400° C). Comparatively short very high power terminations can be produced from this material.

Foamed absorbing materials that operate over the frequency range 2,500 to 70,000 Mc/s, were shown by Plessey. Power absorbed below and above 10,000 Mc/s was claimed to be better than 99 per cent and 99·7 per cent. Type AF20 is made up of foamed polystyrene with carbon loading, the surface being shaped to give a transition from free space into the solid material. A foamed rubber type is also available; it is heavier but more flexible.

Increased use is being made of optical components made in arsenic trisulphide. Barr and Stroud Limited were displaying components in this material. The firm say they can generally supply components of larger dimensions than is possible with crystalline materials. The usefulness of this material in the infra-red has been increased by applying anti-reflection coatings to the surface, thus gaining an increasing transmission of the order of 10 per cent per surface.

Edwards High Vacuum Limited displayed a refractory vapour source for the evaporation of large quantities of aluminium. They claim the equipment overcomes the difficult problem of attack by molten aluminium and the evaporation rate of 2g/min has been achieved with 10 kW for seven hours before the renewal of a relatively inexpensive carbide plug is required. The same firm showed a number of applications of thin films. Alloys of nickel and chromium have been deposited on flexible or rigid resin-bonded glass laminates to form electrical resistance that can be readily cut to shape. An electro-luminescent panel using vacuum deposited coatings for the electrodes was shown: transparent semi-conducting cadmium oxide was used for the front layer, and aluminium for the back layer. The films will burn away and self-heal should the organic dielectric layer break down. Evaporated phosphor films may be prepared when the phosphor material volatilises without undue separation. An example was shown of a manganese activated phosphor film prepared by vacuum evaporation.

Semi-reflecting films were demonstrated by Hilger and Watts Limited. Both semi-reflector and di-electric films were shown. Metal oxide films were chosen to give maximum efficiency with quarter-wavelength films at the reflectivity desired. In most general use are titanium oxide films giving reflectivity of 40 per cent and silicon giving a reflectivity of about 60 per cent. The exhibit showed how the reflectors could be used to view an object and, at the same time, read instruments superimposed on the field of view. With a camera at the side of the viewer opposite to the observer, the object and the instruments could be photographed simultaneously.

Oxide and metal film potentiometers of the photographically-meandered as well as the infinite-resolution type, were shown by G. V. Planer Limited. Advantages of these elements are high attainable resistance per unit area and good stability and wear characteristics. Temperature coefficients of the oxide type are between 0 and 100 ppm/° C.

NICKEL PLATING USING NICKEL CARBONYL

A process involving the deposition of metal coatings on objects, and concerned particularly with the deposition of nickel, has been made the subject of patent application No. 11438/56 by the United Kingdom Atomic Energy Authority, 11 Charles II Street, London, S.W.1. The originator of the process is Mr. L. W. Owen and it was demonstrated at the Physical Society's Exhibition. The nickel coatings are obtained at temperatures of the order of 180° to 250° C by the decomposition of an atmosphere containing nickel-carbonyl vapour. The pressure of this atmosphere is maintained preferably below 10 mm of mercury while the deposition of the nickel is proceeding, and a pressure of between 1 mm and 3 mm is stated to be particularly desirable.

The object to be plated is subjected to a preliminary heating in a reaction vessel evacuated to a very low pressure, namely below 10^{-2} mm, and preferably below 10^{-3} mm, to effect the removal of gases adsorbed on the object. Subsequently a stream of nickel-carbonyl vapour, with or without a diluent gas, is admitted to the reaction vessel. The gases leaving the reaction vessel should be heated to decompose any residual nickel carbonyl and they then pass to an extraction system.

Giving an actual example of the working of the process, the Atomic Energy Authority state that a solid-copper cylinder 1 in in diameter and ½ in in length was degreased in trichlorethylene vapour, placed in the reaction vessel and heated to 400° C for 20 minutes. It was then allowed to cool to 225° C and nickel-carbonyl vapour admitted. The pressure in the reaction vessel was between 1 and 2 mm of mercury and the flow of carbonyl vapour was at a rate of 3 grammes per hour with 0·5 litre of carbon monoxide added. When the desired thickness of coating had been obtained, the cylinder was allowed to cool to about 50° C before air was admitted to the chamber.

The adhesion of the coating to the copper, it is stated, was good and the coating could be machined. The deposition of the nickel was at a rate of 0·88 gramme per hour, equivalent to 1·3 thousandths of an inch per hour on the cylinder of the dimensions adopted. The efficiency was 85 per cent. It is claimed that coatings well over 0·1 in thick can be deposited satisfactorily.

The process, it appears, has particular application to the deposition of nickel coatings on uranium surfaces. At the conclusion of the deposition, in one of the methods employed, the object is subjected to heat treatment *in situ* to improve the adhesion of the nickel coating by extending, by interdiffusion, the depth of the interfacial nickel and uranium zone. This can be achieved by heating at a temperature above 300° C, preferably between 500° and 600° C, for 30 minutes and cooling before allowing the admission of air into the reaction chamber.

The invention is available to industry by application to the Authority's patents exploitation officer.

ALUMINIUM WATER PIPELINE ON A CANADIAN OILFIELD

In Alberta, Canada, upwards of 16 miles of 6 in and 4 in aluminium-alloy pipe have been laid underground to increase the flow of oil from an oilfield by forcing water underground to increase the pressure on the oil pool. The water is drawn from the River North Saskatchewan, filtered and pumped through the 6 in aluminium pipe under a pressure of 500 lb/sq in and the 4 in branch lines terminate at several injection wells where high-pressure water pumps force the water down into the oil-bearing strata at a pressure of over 1 ton per sq in. This artificially increases the sub-surface pressure and augments the yield from each producing well.

The water pipeline runs through clay, swampy soil and sandstone, and aluminium was chosen on account of its corrosion resistance, both internally and externally, and the ease with which the pipes could be handled and butt welded, and their flexibility.

A cinema film depicting the laying of the pipes, entitled " Put this in Your Pipe," and made by the Aluminum Company of Canada Limited, the suppliers of the pipe, was shown in London recently, under the auspices of Aluminium Union Limited, The Adelphi, John Adam Street, London, W.C.2. A second film, entitled, " High-Speed Aluminium Welding," showed the most recent techniques of argon tungsten-arc, inert metal-arc and other modern processes employed for the welding of aluminium structures, and tubes, pipes and other equipment.

LURGI GAS-MAKING PLANT IN SCOTLAND

The decision to build a Lurgi high-pressure complete-gasification plant at Westfield, Fife, near Loch Leven, during the next five years, marks a new stage of progress in the development of the Scottish gas industry, and the gas-grid area which the new plant will eventually supply extends from Dundee and Perth in the north to Cumbernauld in the south, and is bounded by the coastline of the county of Fife.

The installation will be erected in two stages and the construction of the first is expected to be completed by July, 1960, when 15 million cu ft of gas a day will be produced. After the erection of the second stage, which is expected to be completed by September, 1962, the Lurgi plant will be producing 30 million cu ft a day.

The main contract for the new works has been awarded to Humphreys and Glasgow Limited, Carlisle Place, London, S.W.1. In addition to the gas-making plant, the contract includes all civil engineering work and buildings, electricity-generating plant, and every operation in erecting the works on a site which is now open country.

The process employed in the new gas plant was originated in Germany and has been developed by the Lurgi Gesellschaft für Wärmetechnik m.b.H., Frankfurt-am-Main, with which firm Humphreys and Glasgow, in association with the Power Gas Corporation Limited, have reached an agreement, and it is planned that the gas plant will be fabricated in the United Kingdom.

The coal to be gasified at Westfield is a low-grade open-cast material containing up to 25 per cent of ash and 16 per cent of moisture and it is unsuitable for a normal carbonising plant. The coal will be taken directly to the new Westfield gasworks by belt conveyor where it will be crushed and screened and divided into two streams. That to be used in the gas generators being between ⅝ in and 1¼ in and that to be used in a boiler plant, for steam raising, being ⅛ in and below.

The coal is completely gasified in the Lurgi generators at a pressure of 25 atmospheres in a continuous stream of oxygen and superheated steam, the oxygen being supplied by two air-separation plants. As all the carbon in the original coal is converted into gas, there is no coke and the residue is purely ash. The ash collected from the gas generators and the boiler plant will be returned to the open-cast workings.

The heat contained in the crude gas from the generators will be used to produce steam in waste-heat boilers and tar, oils, ammonia and benzol will all be recovered from the gas. The proportion of hydrogen in the gas is increased by a catalytic conversion plant and the carbon dioxide produced, together with the carbon dioxide originally contained in the crude gas and the bulk of the hydrogen sulphide present, are absorbed in a hot potassium carbonate solution in a Benfield plant.

When it leaves the Benfield plant, the gas will have a calorific value of about 400 B.t.u. per cu ft. Enrichment by the hydrogenation of oil will raise the calorific value to about 700 B.t.u. per cu ft, but before distribution, the gas will be diluted with nitrogen, obtained as a by-product in the air-separation plants, to the normal calorific value of town gas, namely, 450 B.t.u. per cu ft.

FIFTY YEARS OF INSTITUTE OF METALS

The programme for the Golden Jubilee spring meeting of the Institute of Metals, to be held in London from Monday, 28 April, to Friday, 2 May, has now been issued. The proceedings will open, on the first day, at 8.15 p.m., at the Royal Institution, Albemarle Street, London, W.1, when Professor R. S. Hutton, an original member and a Fellow of the Institute, will deliver the " Golden Jubilee Lecture." On the morning of the second day, Tuesday, 29 April, the retiring President, Dr. L. B. Pfeil, O.B.E., F.R.S., will occupy the chair at the annual general meeting of the Institute, at Church House, Great Smith Street, London, S.W.1, and after a business meeting, Marshal of the Royal Air Force Lord Tedder, G.C.B., will be inducted into the chair as the new President. In the afternoon, at 3, Professor A. G. Quarrell, of Sheffield, will deliver the May Lecture, at Church House, S.W.1, on " Fifty Years of Metallurgical Science."

The whole of Wednesday, 30 April, and Thursday, 1 May, will be devoted to the reading and discussion of papers at Church House, and, at 7.15 p.m. on 1 May, the Golden Jubilee banquet will be held at Grosvenor House, Park Lane, London, W.1. At this, the principal guest will be Lord Hailsham, Lord President of the Council.

All-day visits to metallurgical and engineering works and other places of interest have been arranged for Friday, 2 May.

ADDITIVE GIVES STRONGER OIL FILM

A new additive, called Addi-V.J., consisting of molybdenum disulphide in colloidal form with other substances, has been introduced by Senol Limited, 22 Charlwood Street, London, S.W.1. When added to an ordinary lubricating oil the new product, it is pointed out, increases the film strength of the oil and enables it to withstand high temperatures and loads without breaking.

The additive is available for use in connection with petrol and diesel engines and their associated transmission lines. Various greases, also based on molybdenum disulphide, are produced for chassis lubrication, wheel bearings and high-temperature applications. All these preparations, it is claimed, possess the very definite ability to remain on bearing surfaces and to provide the best possible protection under the most adverse conditions. Should the oil supply fail, the MoS_2 in Addi-V.J. will prevent seizure and ensure lubrication for some considerable time.

Research and Development

FATIGUE TESTING MACHINE FOR HOT SHEET

Alternating Bending Stresses

By K. W. Mitchell, B.SC.(ENG.), WH.SCH., A.M.I.MECH.E., *and H. King*, ASSOC.M.C.T., A.M.I.MECH.E.*

The machine described below was primarily designed to provide a reliable but relatively inexpensive piece of equipment for subjecting sheet materials to alternating bend stresses at elevated temperatures, with particular reference to the effect of surface coatings on the fatigue strengths of steels at 650° C. Secondary considerations affecting the design were provisions for carrying out tests at room temperature on sheet material down to No. 20 s.w.g., and also means of readily applying a mean stress if such a stress system were required.

The machine was designed to give a constant deflection of variable magnitude up to $\pm$ 0·4 in with the corresponding load limited to $\pm$ 4 lb The constant-deflection design was chosen in preference to the constant-load type which operates at the resonant speed of a spring mass system requiring a variable-speed direct-current motor drive, thus necessitating an a.c./d.c. converter set and control gear.

With the constant-load or constant-deflection type of machine the fatigue specimens have to be calibrated before testing, and, from the calibration, the relationship between the surface stress over the gauge portion of the specimen and the deflection can be found assuming that the strain induced in the specimen is elastic and that the theory of elastic bending holds. It may well be that at elevated temperatures a certain amount of plastic deformation is present and that the stress so calculated is not the true stress but a nominal value and this is especially true when oxidation occurs during testing. In the constant-load machine oxidation will reduce the thickness and hence the section modulus and consequently the surface stress f will increase inversely as the square of the thickness t, i.e. ft^2 = constant, and a further increase in stress will occur with the propagation of a fatigue crack. In the constant deflection type machine the surface stress will decrease in direct proportion to the thickness, i.e. f/t = constant, and there will be a further reduction when a fatigue crack forms. The nominal stress per unit of deflection is proportional to the modulus of elasticity and this is assumed to be constant. Karius, Gerold and Schulz (1944)† have found that the modulus of elasticity for ferrous and non-ferrous metals subjected to alternating bending progressively decreased tending asymptotically towards a definite limiting value as the number of cycles was increased. Consequently, for fixed deflection alternating bending a decrease in the modulus of elasticity will result in a proportional decrease in the surface stress, while in the constant-load machine there will be no alteration in surface stress due to a modulus change.

For comparative tests on the effect of surface treatments the nominal-stress value basis for assessing the relative fatigue behaviour of materials is adequate, and hence the constant deflection type of machine is satisfactory.

The chief components of this machine are a mounting block for holding the specimen, a mechanism for producing alternating bending, driven by an alternating-current synchronous motor, a furnace and associated temperature regulation and control equipment, and electrical gear for counting the number of cycles, and for stopping the machine when the specimen fractures, and a cathetometer for measuring the deflection of the specimen. Photographs of the machine in use for room and elevated temperatures are shown in Figs. 1 and 2, respectively.

The machine shown diagrammatically in Fig. 3 set up for tests at elevated temperatures, consists of a rigid mounting block which holds the fixed end of the specimen. The specimen is clamped between two steel plates which are insulated electrically and thermally from the mounting block by Sindanyo plates. The free end of the specimen is connected to a tie rod between an upper spring and knife-edge. The other end of the tie rod is connected to a hinged lever between a lower spring and knife edge. Both the hinged lever and the free end of the specimen are grooved to accommodate the knife edges. The hinged-lever bearing is mounted on a slide block, and, by rotating a knob below it, its height can be adjusted; in consequence the free end of the specimen can be raised or lowered when the machine is operating. The other end of the hinged lever is connected to a connecting rod via a self-aligning ball journal. The big end of the connecting rod is connected to the crank-pin slide, of an eccentric, via a roller journal. The amplitude of bending of the specimen is governed by a regulating knob on the eccentric, which adjusts the position of the crank-pin slide, and hence the crank-pin radius. The eccentric is driven by a $\frac{1}{3}$ h.p. three-phase synchronous motor, running at 2,880 rev/min via a shaft connected to the motor by a flexible coupling, and carried by two self-aligning double row ball journals.

The furnace of the apparatus consists of a refractory tube on which is wound the heating

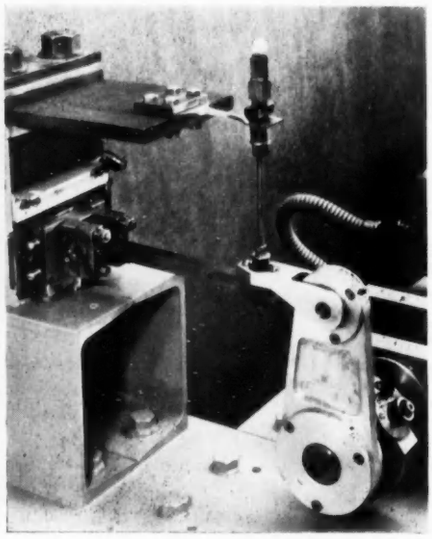


Fig. 1 (left) Alternating flexure fatigue testing machine arranged for testing at room temperature.

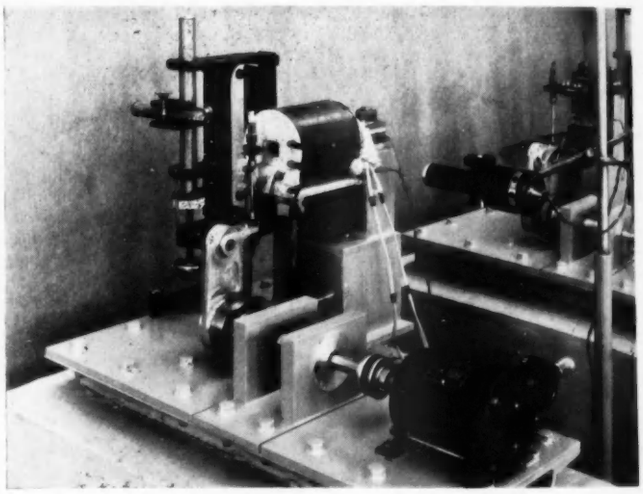


Fig. 2 (right) Machine arranged for testing at elevated temperature.

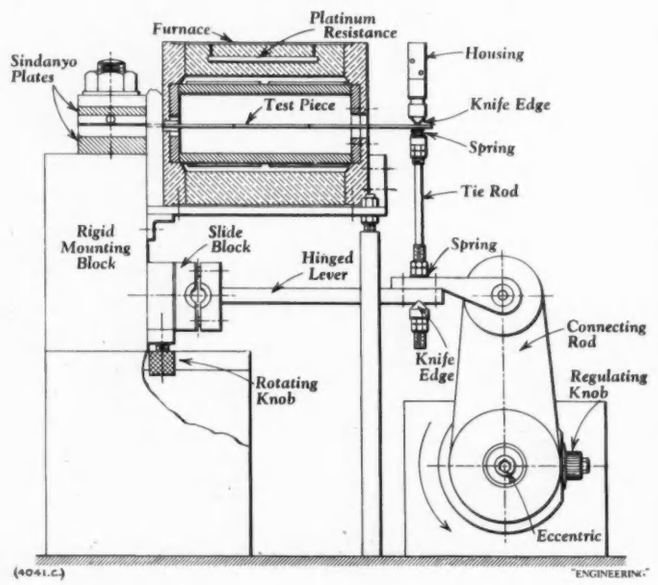


Fig. 3 (below) Diagrammatic view of testing machine assembly.

* Mr. Mitchell is chief engineer and Mr. King is an investigator at the Fulmer Research Institute, Stoke Poges, Buckinghamshire.

† A. Karius, E. Gerold and E. H. Schulz, *Arch. Eisenhütten*, vol. 18, page 113 (1944-45).

coils; it is held between Sindanyo end covers by a tubular outer case. The gap between the tube and the case is filled with kieselguhr and, adjacent to the tube, is mounted a platinum resistance connected externally into the bridge circuit of a " Prosser "-type proportional temperature controller. The furnace windings are split up into two zones in order to obtain uniform heating of the gauge portion of the specimen, and the power input to each zone is regulated by a 500 watt Variac transformer, one to each zone. The temperature controller operates a relay which switches into the common neutral of the heating circuit a resistance, which is sufficient at the normal voltage settings of the Variac transformers, to cause a reduction in the furnace temperature. The variable resistance in the bridge circuit of the temperature controller is adjusted at the required temperature to cause the operating relay to have equal on-off periods.

The temperature of the specimen is obtained from two Chromel v. Alumel thermocouples strapped one at each end of the gauge length.

The number of cycles to fracture of the test specimen is obtained by multiplying the running time by the motor speed. The running time is given by a time clock connected in parallel across one phase of the motor. The motor is shut off when the test piece fractures by breaking an 8 volt relay circuit of which the test piece forms a part. This relay, when it opens, breaks the coil circuit in the motor starter. (The schematic wiring diagram is shown in Fig 4.)

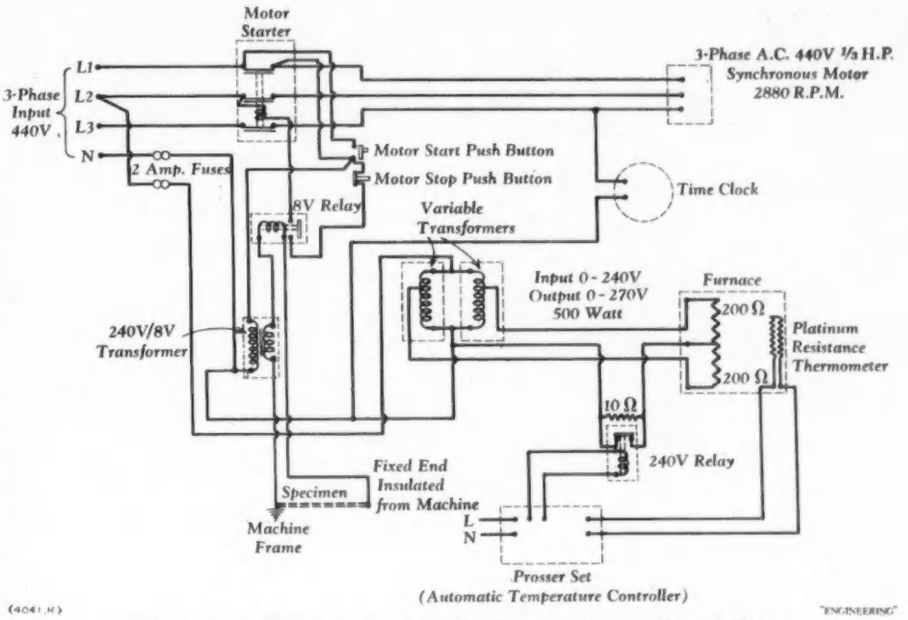


Fig. 4 Circuit diagram for alternating flexure fatigue testing machine.

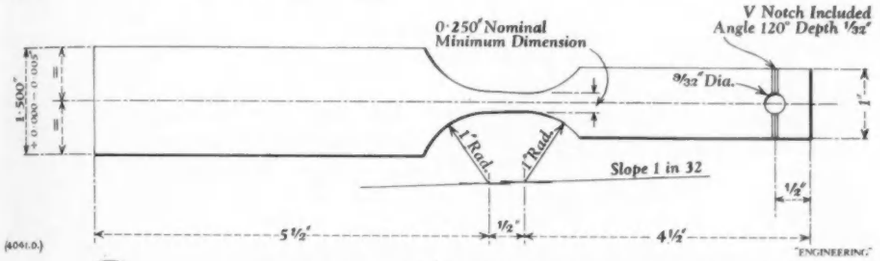


Fig. 5 (above) Strip test specimen for use at elevated temperatures.

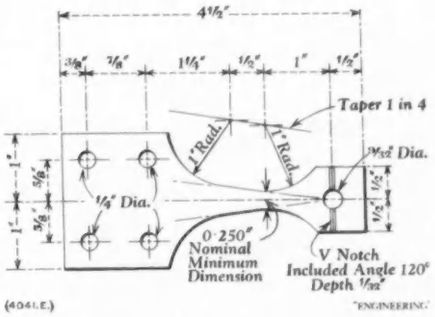
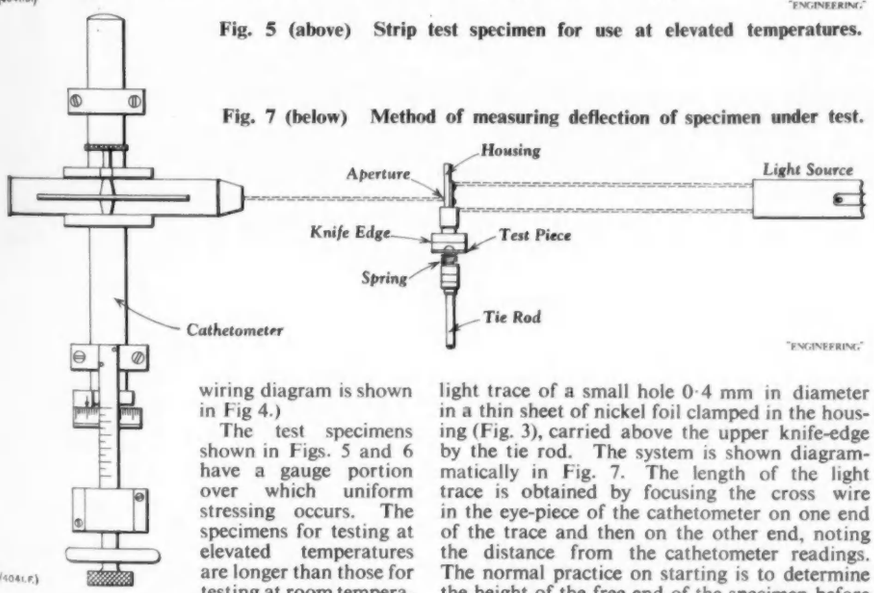


Fig. 6 Specimen for use at room temperature.

Fig. 7 (below) Method of measuring deflection of specimen under test.



To accommodate the shorter specimens used for tests at room temperature without the furnace, an extension plate is fixed to the mounting block and to it are bolted the specimens.

For the static calibration of the test specimen, the tie rod in Fig. 3 is replaced by a rod carrying a weight pan at its lower end. The bending moment is applied to the specimen by placing weights on the scale pan and the corresponding deflection of the specimen at the free end determined with a cathetometer. From the calibration the deflection to give the required nominal surface stress can be determined.

When the machine is operating, the deflection of the specimen is determined by measuring the light trace of a small hole 0·4 mm in diameter in a thin sheet of nickel foil clamped in the housing (Fig. 3), carried above the upper knife-edge by the tie rod. The system is shown diagrammatically in Fig. 7. The length of the light trace is obtained by focusing the cross wire in the eye-piece of the cathetometer on one end of the trace and then on the other end, noting the distance from the cathetometer readings. The normal practice on starting is to determine the height of the free end of the specimen before attaching the tie rod, afterwards, at zero eccentric, fit the tie rod, etc., and adjust the height of the specimen until it coincides with the height of zero stress. Then focus the cathetometer on the hole in the nickel foil, note the readings for the apex and base of the hole, add algebraically on to each value the required deflection and then adjust the eccentric to give 90 per cent of the required deflection—run the machine and note the deflections above and below the zero deflection. These latter are greater when running owing to the dynamic unbalance of the reciprocating and rotating parts. Adjust the height of the " free " end of the specimen while running, by rotating the knob (Fig. 3), until the recorded deflections are of equal value about each side of the original zero position. Stop the machine and readjust the eccentric to give the required deflection. The required value of the deflection to within 0·01 mm can be obtained by an experienced operator by about four adjustments to the eccentric. If it is not essential to get an absolute value for the deflection, and hence the stress, the eccentric need only be adjusted once. If a mean stress other than zero is required, this can readily be done by adjusting the height of the free end of the specimen.

The test results obtained with this type of

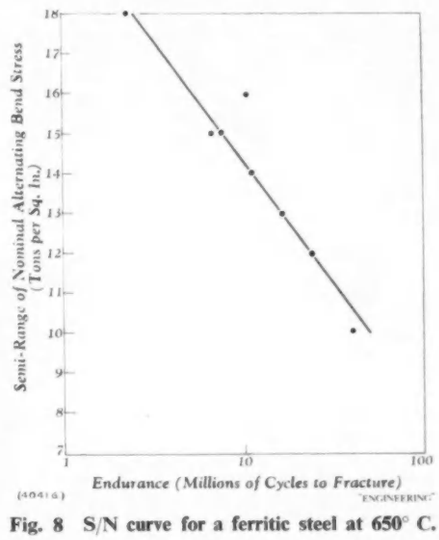


Fig. 8 S/N curve for a ferritic steel at 650° C.

Continuing

Research and Development

machine have been very satisfactory and have given the required information when operated at room temperature or at elevated temperatures. A typical S/N curve obtained for a ferritic steel at 650°C is shown in Fig. 8, in which it is noted that the scatter of results is small.

Four of these machines have been fully occupied for three years with very little operating trouble other than a renewal of the big-end bearings and the re-grinding of the knife edges. Machines have been run continuously for tests in excess of 3 months at 650°C without the failure of any component.

If required, the design could be modified to incorporate a weigh-bar, in series with the specimen, in order to measure the bending moment during test, although this might lead to difficulties when operating at elevated temperatures.

Acknowledgment.—This article is published by permission of the directors of the Fulmer Research Institute.

THERMOMETER IN THE SKY

The reports that the United States satellite Explorer has been radioing back are expected to give valuable information about the temperatures in the ionosphere and the exosphere. It has been estimated that the layer of heat which the satellite passes through twice on each of its 12 daily orbits has a temperature of 3,000° F. Thermistors are used to record temperature changes: one is cemented on the outside of the satellite's instrument package, three others are located inside it. The information about the temperatures inside and outside the satellite is valuable because they affect the operation of the scientific instruments. If the instruments should stop functioning, scientists at ground receiving stations would know the temperatures existing at the time of failure, and so be able to improve future satellites.

Objects in space absorb heat by radiation. Light coloured objects reflect heat rays and so remain cold; dark coloured objects absorb heat rays and become hot. To avoid extremes of temperature, the Explorer is insulated by strips of white zirconium oxide, a material that reflects a high proportion of incident radiation. The light strips alternating with the dark grey casing give the satellite an overall grey colour that should give a reasonable operating temperature for the instrument package.

When the satellite was launched on 31 January, the low-power transmitter was expected to continue in operation for about two months. The high-powered transmitter was expected to last only two or three weeks. In fact, its signal on 108·03 Mc/s continued without interruption for the first 12 days and then could not be heard. It was silent for 11 days, then resumed transmission on 23 February, only to become silent again on 26 February. On 28 February the minitrack radio station at San Diego, California, again picked up its signal.

The standard transmission frequency signals sent by the Explorer's 108 Mc/s radio transmitter are used for keeping track of the satellite. The signals are picked up by the minitrack and microlock stations and sent to the Naval Research Laboratory in Washington, which in turn forwards them to the Vanguard computing centre in Washington, where Explorer's orbit is calculated.

When the computing centre has completed its forecasts, it sends them to the many " moon watch " teams in various parts of the world, and also to the stations equipped with Baker-Nunn satellite tracking cameras. Twelve of these stations are planned for the I.G.Y. but not all of them are yet in operation. The photography programme is being conducted by the Smithsonian Institution's Astrophysical Observatory at Cambridge, Massachusetts.

CAMBRIDGE ENGINEERING RESEARCH

The work of the University of Cambridge, Department of Engineering, continues to exert a marked influence on research in the fields of aeronautics, electricity, materials, mechanics, servo-mechanisms and control, soil mechanics, stress analysis, structures and thermodynamics. Professor J. F. Baker, Head of the Department, in his report for the year 1956-57, provides a useful summary of this work which has been described in greater detail in publications by his staff—of which there are references to as many as 80—listed at the end of the report.

One is left in no doubt as to the practical implications of the investigations undertaken and the whole programme reveals a happy balance between pure and applied research. For example, the examinations which have been made of gold/bismuth-oxide films by electron diffraction provide for reproducibility of the film structure by suitable control of sputtering conditions. The process is of importance in the production of electrical-conducting transparent films on glass for de-icing and de-misting of aircraft control cabin windows.

In the report there is also reference to investigations into the behaviour of various carburettors when fitted to an engine installed in snow-tractors—work which was done for the benefit of the Trans-Antarctic Expedition. Experiments on the maintenance of laminar flow by means of suction surfaces consisting of finely drilled light-alloy sheet have been continued, using Vampire aircraft, while full-scale flight experiments on the use of suction to obtain high lift coefficients have been planned, using suitably modified Auster aircraft.

An interesting feature of the work reported, is the increasing use being made of automatic computers such as EDSAC1 for computations arising from a variety of research projects. An interesting example is the use of this computer in an analytical approach to the solution of problems concerned with stresses in buttress dams and for calculations arising from the application of theoretical actuator-disc methods to air compressor-blade vibration during stall propagation.

Another interesting example of the use of computers by the Engineering Department is the research on the behaviour of flexible tubes containing oil and floating water. This work was undertaken to assess the possibility of transporting oil in flexible barges under tow and the results of this work have recently been given prominence in the daily Press. The experimental work was done jointly with the National Physical Laboratory, while the department also made a theoretical study of the stability of this type of barge and computed stresses in the skin.

Among other interesting problems receiving attention is that of milling-machine chatter, a special problem in non-linear vibration; and a test rig for examining the dynamics of lathe tools is being constructed. Of interest in the field of automation are the theoretical and experimental studies which are being made to enable control systems of higher performance to be designed for use in industry and by the Services ; a typical example being the oscillation of hydraulic piston valves used in control mechanisms. Work on the shear strength of soils also continues, using a new five-ton triaxial machine, and a model seepage tank has been made to study the stability and seepage through earth dams, coffer dams, etc.

A number of researches are being sponsored by the United Kingdom Atomic Energy Authority on such items as the dynamics of ionised gases and the use of liquid mercury as a heat-transfer medium.

It should be noted that when the Vice-Chancellor of Cambridge University opened an extension to the Engineering Laboratory, on 25 February (see ENGRG., 28 Feb., p. 275), there was demonstrated a practical outcome of studies which had been in progress in the department into the many aspects of the behaviour of mild-steel structures stressed beyond the elastic limit. For the new four-storey central wing which forms part of this extension, is the first multi-storey steel-framed laboratory or office building to have been designed by the plastic method developed by the department. This work has now been extended to investigations into the design of rigid connections for multi-storey framed structures, with particular results to the size of stiffeners and amount of welding; studies have also been made of the overall stability of structures in the partially plastic state, where the slenderness of the structural frames significantly decrease the collapse loads as derived by simple plastic theory.

EXPERIMENTING WITH THE GRID SYSTEM

Stability Studies Use 45 MW Generator

Electrical equipment is a complicated thing. But even more complicated is the network resulting from the interconnection of electrical equipment. A large national grid system, for example, makes considerable demands on its designers when they aim to produce the best working conditions. And their task is not made easier by the size of the system; or by the fact that full-scale tests are rarely possible because the system is always in use. The designer would like to know what happens to the system when violent overloads occur in part of it; but the consumer extracting power would not welcome any fluctuations in his own supply.

Stability is the chief concern of the system designer. At present, the only satisfactory way he can examine the stability of a system is to use a network analyser, usually a single-phase analogue machine. However, although some full-scale system tests have been carried out—producing valuable information on various aspects of abnormal conditions—none have been staged primarily for finding out how accurate network analyser studies are. Or rather, none had been carried out prior to August Bank Holiday 1956.

A panel in the Electrical Research Association decided it would be worthwhile carrying out tests to see how closely network analyser results agreed with actual performance. Panel V/Da was the one concerned—it deals with system constants—and the co-operation of the Central Electricity Authority was sought for the provision of a section of the British Grid system in which an isolated generator could be connected, so that instability could be produced under steady-state and transient-fault conditions without causing any great disturbance. It was found that Cliff Quay (Ipswich) generating station was suitable. The chief engineer of the C.E.A. gave permission for the tests to be carried out there from 4-7 August, 1956.

Accounts of the organisation of the tests and the results obtained are given in two papers to be published in the *Proceedings* of the Institution of Electrical Engineers (vol. 105, part A, 1958). The first is " The Organisation for Large-Scale Grid System Tests," by F. H. Last, E. Mills, and N. D. Norris. The second is " Results of Full-Scale Stability Tests on the British 132 kV Grid System," by F. Busemann and W. Casson.

A 45 MW generator was connected to the main system through a 150 mile line and faults of various types were applied with the generator on

full load. It was found that confidence could be placed in network analyser results but that normal generator control-panel instruments were inadequate and could give misleading information during unstable conditions. The tests also showed that operation staff at large generating stations could benefit from being trained to meet and rectify generator instability conditions. Important information about the characteristics of cylindrical-rotor machines was also obtained.

Several incidents demonstrated to all concerned that the work was not being carried out in a laboratory. During one day, lightning was reported in south-east England and although tests were continued for a short while they were abandoned when continuous checks confirmed that the storms were moving into the area of the tests. The protective equipment was then put back in service as quickly as possible and the system restored to normal. The last trip link had just been inserted for the main protection of the Cliff Quay–Yarmouth 132 kV feeder when the line was struck by lightning. Protective equipment functioned correctly. Soon after, both the Cliff Quay-Sundon 132 kV feeders tripped owing to lightning. All circuits, including the test generator, cleared correctly. Testing was later resumed; but there had been convincing demonstration that the normal hazards of system operation must be catered for in planning system tests.

The tests were made in three stages. First a study was made of the steady state stability of a generator connected to a system, both directly and through a long transmission line—with and without automatic voltage regulators. At specified loads the excitation was gradually reduced until pole-slipping started. All observations were made visually at this stage. Second, a study was made of the transient stability of the generator, with and without automatic voltage regulators, following the sudden insertion of a high line reactance in the system. This was accomplished by adjusting the load and excitation of the test machine while in parallel with others and then suddenly inserting, by opening a circuit breaker, 150 miles of line in series with the test machine. Third, a study was made of the transient stability of the generator, with and without automatic voltage regulators, coupled to the system through a high line reactance, resulting from the application of system faults. In this set of results the machine was loaded to specified conditions and 132 kV faults of various kinds were applied. The records were obtained automatically in this and the preceding stage. During the test the remaining generators at Cliff Quay were available for normal commercial operation; and the station was assigned a loading programme that varied from 70 to 120 MW, depending on the time of day.

"The pole slipping which resulted from some of the tests was a considerable strain on the electrical control-room engineer," write the authors of the first paper, "the normal instruments provided on a generator control panel gave a very alarming picture. This was aggravated by the knowledge that violent fluctuations in current were being produced in the other generators in the station and in the feeders of the system. The most useful of the panel instruments, however, was the field ammeter, which did give an indication of whether or not the rotor was pulling into step. Later in the series of tests, a chart recorder was installed near the test generator control panel and a record was taken of the rotor angular position. When this was oscillatory, a valuable indication was given to show whether the machine was tending towards or away from stability."

In no test was it found necessary to trip off the test machine. But on some occasions corrective action—by increasing the field current or reducing load—had to be taken to restore stable conditions. Stability was maintained with full load on the machine when the reactance of 150 miles of line was suddenly inserted between it and the system, provided that the excitation was sufficient for steady-state operation with the line. Reactive power consumed by the machine at the steady-state stability limit was about 15 per cent higher than calculated values because of saturation effects. During asynchronous operation with open field up to 30 MW the slip remained very low.

CONDENSER BUSHINGS EXAMINED

Many 132 kV condenser bushings have been in continuous operation on the British Grid System for 25 years or more. Their main insulation is synthetic-resin bonded paper. In general they have given excellent service, but there have been some failures. These cause loss of supply and may harm personnel and equipment. So an extensive investigation was undertaken to work out the best test methods. The work is described in a paper "Laboratory and Field Tests on 132 kV Condenser Bushings," by Mr. J. L. Douglas and Mr. A. W. Stannett. Both authors are at the Central Electricity Authority Research Laboratories. The paper is to be published in 1958 in volume 105, part A, of the *Proceedings* of the Institution of Electrical Engineers.

Measurements were made in the laboratory on a series of bushings having the same overall dimensions. All had been manufactured during 1929-31. Careful study was given to the variation of power factor with voltage, and five types of variation were recognised. The authors discuss each type in detail.

The destructive examination of bushings with typical characteristics helped in the interpretation of non-destructive tests. It was shown that water penetration can lead to direct failure in service. But poor tap-point connections and the presence of voids and oil did not appear likely to lead to rapid failure. Provided regular testing is carried out to detect the onset of the next stage of deterioration (puncture of a section), there is no apparent reason why such bushings should not give years of trouble-free service. Of a sample 86 bushings examined by the authors, 52 per cent were unchanged by their years of service, 20 per cent were definitely faulty and the remaining 28 per cent had defects but were fit for service.

One bushing that failed in service was found to contain sequences of self-healed punctures. Other bushings dissected showed the same effect. The authors say that it would appear that when an eroded path penetrates the section there is a risk that sufficient energy will be liberated to cause the foil to volatilise at the point of impact. It is possible for the eroded hole to continue through the next section at an ever increasing rate. Rapid complete breakdown can follow.

This defect is not revealed by the non-destructive tests normally used, although it is possible that it might be shown with a discharge detector. In another type of defect, foils have been found to be disintegrated. This can be detected by radiography but does not appear to effect the power factor and capacitance of the bushing.

Other tests proved useful as laboratory tools. Radiography enabled misplaced foils, cracks, and built-up insulation to be detected and located. The discharge detector confirmed that the curve of power factor variation with voltage shows the presence of discharging voids for all practical purposes. Infra-red photography proved useful, but it could only be used when tracking below the surface was suspected.

The laboratory testing principles were adapted to testing in the field. In most cases measurements were made on the low voltage side of the test object permanently connected to earth, the bushing being completely assembled and mounted in the breaker tank. Thus extraneous magnetic and electric fields were present. A 30 kV portable Schering bridge was developed and is described by the authors. It was not found possible to find a power-factor rejection limit.

Investigations showed that items such as breaker oil, explosion pots or de-ion grids, lift rods and arc shields all contribute to the higher power factors of installed bushings. For instance, lowering the level of the oil in the circuit-breaker tank might reduce the bushing power factor by 30 per cent.

In such circumstances it is not possible to define a power-factor rejection limit. If the limit is fixed at 0·03, say, several faulty bushings would be left in service while an appreciable number of sound ones would be removed unnecessarily. Change of power factor with voltage is an indication of punctured sections, and therefore if the power factor varies by more than 0·005 between 5 and 30 kV, the bushing is removed from service. If the variation is slightly less the bushing is classified as being in a doubtful condition and should be rechecked every two or three years. The power factor or change of power factor with voltage is not related to the amount of insulation deterioration.

The authors remark in conclusion that if tests are carried out on site at one voltage only, it is better to use a low one. Power factor tests at working voltage are of little value. They say that annual insulation-resistance measurements and inspection of bushing oil-levels will detect the conditions which lead to surface tracking. Annual site measurements of capacitance will detect punctured sections of condenser bushings.

SPACE TRAVEL CONFERENCE

The problems and possibilities of travel through outer space are to be put before young people between the ages of 16 and 23 at a morning conference to be opened by the Duke of Edinburgh, on 14 April, at the Royal Festival Hall, London. The conference is being organised by the Air League of the British Empire, of which Prince Philip is Patron.

Marshal of the Royal Air Force Sir Dermot Boyle, Chief of Air Staff, will preside, and there are to be four speakers. Professor W. H. McCrea, Royal Holloway College, will discuss the nature of outer space and its problems. Mr. J. E. Pateman, senior technical executive (guided flight), Elliott Brothers (London), Limited, will describe control systems and navigation. The other two speakers are Mr. Arthur C. Clarke, former president of the British Interplanetary Society and one of the foremost contemporary space-travel writers and speakers, and Mr. D. G. King-Hely, of the Royal Aircraft Establishment. These four speakers will subsequently form a "brains trust," under the chairmanship of Sir Arnold Hall, former director of the Royal Aircraft Establishment.

The conference opens at 10.30 a.m. and will last until about 1.30 p.m. Invitations to send parties have been issued to schools, technical colleges, universities, and companies with apprentice-training schemes. Individual applications will also be accepted. Tickets are 7*s.* 6*d.* each (5*s.* to members of the Air League). Early application is advised, to the Air League of the British Empire, Londonderry House, 19 Park Lane, London, W.1.

TESTING pH METERS

A. M. Lock and Company, Limited, Oldham, Lancs., make an instrument for testing pH meters. They claim that tests can be made very quickly with it and that the user does not require any electrical knowledge.

The test set consists basically of a long-life dry cell across which is connected a number of high stability resistors, to form a potentiometer. A switch connected across the resistors selects an increasing number of millivolts as it is rotated in a clockwise direction. Each switch step corresponds to about 2 pH units.

EXHIBITIONS AND CONFERENCES

This list, in chronological order, appears in the last issue of each month. Events noticed for the first time and alterations of dates, places, etc., are indicated by an asterisk (*). For details of events not included below, reference should be made to ENGINEERING, 31 *January, page* 148, *and* 28 *February, page* 277. *Organisers are invited to send particulars of coming events to the Editor.*

"Birmingham Mail" National Trades, Homes and Gardens Exhibition.—Wed., 2 April, to Sat., 26 April, in Birmingham. Organised by Herbert Daniel Exhibitions Ltd., 3 Clifford Street, London, W.1. Tel. REGent 8611.

Automobile Show, International.—Sat., 5 April, to Sun., 13 April, at New York Coliseum, New York. Organised by the Charles Snitow Organisation, 331 Madison Avenue, New York 17, U.S.A.

***Improving Productivity by Use of Compressed Air, Conference.**—Wed. and Thurs., 9 and 10 April, at Cornwall Technical College, Camborne, Cornwall. Organised by the Institution of Production Engineers, 10 Chesterfield Street, London, W.1. Tel. GROsvenor 5254.

***Society for Applied Mathematics and Mechanics (G.A.M.M.), Annual Meeting.**—Wed., 9 April, to Sun., 13 April, at Saarbrücken. Apply to Professor Dr.-Ing. J. Döor, Mathematisches Institut der Universität, Saarbrücken (Saarland), Germany.

***Detection of Damage in Metals by Low Temperature Electrical and Thermal Resistivity Methods, Conference.**—Thurs., 10 April, at Oxford. Organised by the Low Temperature Group, Physical Society, 1 Lowther Gardens, London, S.W.7. Tel. KENsington 0048.

***Nuclear Energy, Conference on.**—Thurs., 10 April, to Sat., 12 April, at Eastbourne. Organised by the Federation of British Industries, 21 Tothill Street, London, S.W.1. Tel. WHItehall 6711.

Swiss Industries Fair.—Sat., 12 April, to Tues., 22 April, at Basle, Switzerland. Apply to The Economic Division, 18 Montagu Place, Bryanston Square, London, W.1. Tel. PADdington 0701.

Japan International Trade Fair.—Sat., 12 April, to Sun., 27 April, at Osaka. Apply to the Japan International Trade Fair Commission, Honmashi-bashi, Higashi-ku, Osaka, Japan. See also ENGRG., 5 July '57, p. 27.

***Problems of Training, Conference.**—Sun., 13 April, to Wed., 16 April, at The University, Bristol. Organised by the Ergonomics Research Society, Department of Psychology, 22 Berkeley Square, Bristol 8. Tel. Bristol 2-4161.

American Chemical Society, 133rd Meeting.—Sun., 13 April, to Fri., 18 April, at San Francisco. Organised by the Society, 1155 Sixteenth Street, Washington 6, D.C., U.S.A.

Radio Component Show, 15th Annual.—Mon., 14 April, to Thurs., 17 April, at Grosvenor House and Park Lane House, Park Lane, London, W.1. Annual private exhibition organised by the Radio and Electronic Component Manufacturers' Federation, 21 Tothill Street, London, S.W.1. (Tel. ABBey 4226.) No special preview will be held on this occasion. Applications for admission must be made in advance.

DESIGN ENGINEERING

Design Engineering Show, Third.—Mon., 14 April, to Thurs., 17 April, at the International Amphitheater, Chicago. Organisers: Clapp and Poliak, Inc., 341 Madison Avenue, New York 17, U.S.A.

Industrial Textiles Fair, Third.—Mon., 14 April, to Fri., 18 April, at the Royal Albert Hall, Kensington Gore, London, S.W.7. Organised by Trade Fairs and Promotions Ltd., Drury House, Russell Street, London, W.C.2. Tel. TEMple Bar 3422.

Factory Equipment Exhibition.—Mon., 14 April, to Sat., 19 April, at Earl's Court, London, S.W.5. Theme: "Modern Factory Equipment—Britain Challenges the World." Organised by Factory Equipment Exhibitions Ltd., 4 Snow Hill, Holborn Viaduct, London, E.C.1. Tel. CENtral 0354.

***Thermal Insulation Exhibition.**—Mon., 14 April, to Sat., 19 April, at Earl's Court, London, S.W.5. Apply to exhibition offices.

Science in the Use of Coal, Residential Conference.—Tues., 15 April, to Thurs., 17 April, at The University, Sheffield. Organised by the Institute of Fuel, 18 Devonshire Street, London, W.1. Tel. LANgham 7124.

Instruments, Electronics and Automation Exhibition.—Wed., 16 April, to Fri., 25 April, at Olympia, London, W.14. Promoted by the British Electrical and Allied Manufacturers' Assoc., British Industrial Measuring and Control Apparatus Manufacturers' Assoc., British Lampblown Scientific Glassware Manufacturers' Assoc., Drawing Office Material Manufacturers' and Dealers' Assoc., and the Scientific Instrument Manufacturers' Assoc. Organised by Industrial Exhibitions Ltd., 9 Argyll Street, London, W.1. Tel. GERrard 1622.

Brussels Universal and International Exhibition.—Thurs., 17 April, to Sun, 19 Oct., at Brussels. Sponsored by the Belgian Government. General inquiries in Britain to be made to the U.K. Commissioner General, Brussels 1958 Exhibition, 83 Baker Street, London, W.1. (Tel. WELbeck 4420); and space bookings to British Overseas Fairs Ltd., 21 Tothill Street, London, S.W.1. Tel. WHItehall 6711. See also "Brussels Preview," ENGRG., 25 Oct. '57, p. 514.

Audio Fair.—Fri., 18 April, to Mon., 21 April, at the Waldorf Hotel, Aldwych, London, W.C.2. Organised by Audio Fairs Ltd., 42 Manchester Street, London, W.1. Tel. WELbeck 9111.

Home Building Exposition.—Sat., 19 April, to Sun., 27 April, in the Coliseum, New York. Offices of the Exposition: 250 West 57th Street, New York, U.S.A.

Metal Powder Show.—Mon. 21 April, to Thurs., 24 April, at the Sheraton Hotel, Philadelphia. Organised by the Metal Powder Association, 130 West 42nd Street, New York City.

MANAGEMENT

***Management Engineering Conference.**—Thurs. and Fri., 24 and 25 April, at Hotel Statler, New York. Sponsored by the Society for Advancement of Management and the Management Division of the American Society of Mechanical Engineers. Apply to the Society for Advancement of Management, 74 Fifth Avenue, New York 11, U.S.A.

Packaging and Profit, Conference.—Thurs., 24 April, to Sat., 26 April, at the Grand Hotel, Eastbourne. Organised by the Institute of Packaging, 20-21 Took's Court, Cursitor Street, London, E.C.4. Tel. CHAncery 8484.

Casablanca International Trade Fair, 13th.—Fri., 25 April, to Sun., 11 May, at Casablanca. Fair offices: Rue Jules Mauran, Casablanca.

Liège International Trade Fair, Tenth.—Sat., 26 April, to Sun., 11 May, at Liège, Belgium. *Agent:* Mr. R. C. Liebman, 178 Fleet Street, London, E.C.4. Tel. CITy 5889.

Electrochemical Society, General Meeting.—Sun., 27 April, to Thurs., 1 May, at New York. Organised by the Society, 216 West 102nd Street, New York 25.

German Industries Trade Fair.—Sun., 27 April, to Tues., 6 May, at Hanover. *Agents:* Schenkers, Ltd., Royal London House, 13 Finsbury Square, London, E.C.3. Tel. METropolitan 9711.

Health Exhibition.—Mon., 28 April, to Fri., 2 May, at Eastbourne. Organised by the Royal Society of Health, 90 Buckingham Palace Road, London, S.W.1. Tel. SLOane 5134.

Institute of Metals, Jubilee Spring Meeting.—Mon., 28 April, to Fri., 2 May, in London; and Mon. and Tues., 5 and 6 May, at provincial centres. Organised by the Institute, 17 Belgrave Square, Westminster, London, S.W.1. Tel. BELgravia 3291.

Engineering Societies in Western Europe and the United States, Conference.—Mon., 28 April, to Sat., 3 May, in New York. Apply to Colonel C. E. Davies, secretary, American Society of Mechanical Engineers, 29 West 39th Street, New York 18.

Scotland's Own Ideal Home Exhibition.—Wed., 30 April, to Sat., 17 May at Edinburgh. Organised by Herbert Daniel Exhibitions Ltd., 3 Clifford Street, London, W.1. Tel. REGent 8611.

A.S.T.E. Tool Show.—Thurs., 1 May, to Thurs., 8 May, at the Convention Centre, Philadelphia. Organised by the American Society of Tool Engineers, 10700 Puritan Avenue, Detroit 38, Michigan, U.S.A.

British Columbia International Trade Fair.—Thurs., 1 May, to Sat., 10 May, at Exhibition Park, Vancouver, B.C., Canada. Organised by the Department of Industrial Development, Trade and Commerce, Victoria, B.C., Canada. *Representative:* Agent General for British Columbia, 1 Regent Street, London, S.W.1. Tel. WHItehall 6857.

Agricultural Machinery and Equipment Exhibition, 38th International.—Sun., 4 May, to Sun., 11 May, at the "Plaine de Manoeuvres," Etterbeek, Brussels. Organised by the Société de Mécanique et d'Industrie Agricoles, 29 Rue de Spa, Brussels 4.

Hospital Equipment and Medical Services Exhibition, International.—Mon., 5 May, to Sat., 10 May, at Olympia, London, W.14. Organised by Contemporary Exhibitions Ltd., 40 Gerrard Street, London, W.1. Tel. GERrard 4951.

***Designing Equipment for Human Use, Course on.**—Mon., 5 May, to Fri., 16 May, at Engineers' House, The Promenade, Clifton Down, Bristol, 8. Tuition fee £40, excluding accommodation. Apply to the Engineering and Allied Employers' West of England Association at that address. Tel. Bristol 2-5078.

Yorkshire Ideal Homes and Food Exhibition.—Tues., 6 May, to Sat., 17 May, at Leeds. Organised by Modern Exhibition Services Ltd., Manchester House, Burnley Road (Luddendenfoot), Halifax.

Mechanical Handling Exhibition and Convention.—Wed., 7 May, to Sat., 17 May, at Earl's Court, London, S.W.5. Organised by *Mechanical Handling*, Dorset House, Stamford Street, London, S.E.1. Tel. WATerloo 3333.

***Editors, International Congress of.**—Thurs., 8 May, to Wed., 14 May, in Belgium. Organised by the International Federation of Editors, 36 Rue Vivienne, Paris 2e.

Association of Supervising Electrical Engineers, 1958 Conference.—Fri., 9 May, to Sun., 11 May, at the Queen's Hotel, Hastings. Association's headquarters: 23 Bloomsbury Square, London, W.C.1. Tel. LANgham 5927.

Business Efficiency Exhibition, 168th Regional.—Mon., 12 May, to Fri., 16 May, at the Ice Stadium, Nottingham. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate Hill, London, E.C.4. Tel. CENtral 7771.

***International Gas Union, General Meeting.**—Mon., 12 May, to Sat., 17 May, at Karlovy Vary, Czechoslovakia. Address of Union: 4 Avenue Palmerston, Brussels.

1958 British Electrical Conference.—Fri. and Sat., 16 and 17 May, in Brussels. Supported by the British Electrical and Allied Manufacturers' Assoc.; British Radio Equipment Manufacturers' Assoc.; Cable Makers' Assoc.; Electric Light Fittings Assoc.; Radio Communication and Electronic Engineering Assoc.; Telecommunication Engineering and Manufacturing Assoc.; and Water-Tube Boilermakers' Assoc. Apply to the Conference offices: 36 Kingsway, London, W.C.2. Tel. HOLborn 0502.

***Prevention of Occupational Accidents, Second World Congress on.**—Mon., 19 May, to Sat., 24 May, at Brussels, Belgium. Offices: 29 Avenue André Drouart, Auderghem-Brussels, Belgium.

***Automotive Technical Congress, Seventh International.**—Mon., 19 May, to Wed., 28 May, in Paris. Organised by the Société des Ingénieurs de l'Automobile, 5 Avenue de Friedland, Paris, 8e.

***Business Records, Second Conference on.**—Tues., 20 May, at the Connaught Rooms, Great Queen Street, London, W.C.2. Organised by Aslib, 4 Palace Gate, London, W.8. Tel. KNIghtsbridge 0444.

***Works and Plant Engineers, Conference.**—Tues., 20 May, to Fri., 23 May, at the Strand Hotel, Portstewart, near Portrush, Londonderry. Apply to National Industrial Fuel Efficiency Service (N.I.E.F.S.), 71 Grosvenor Street, London, W.1. Tel. HYDe Park 9706.

Royal Ulster Agricultural Show, 91st.—Wed., 21 May, to Sat., 24 May, at the Society's show grounds, Balmoral, Belfast. Offices: The King's Hall, Balmoral, Belfast.

Mechanical Engineering Congress, Seventh International.—Mon., 2 June, to Fri., 6 June, at Scheveningen, Holland. Apply to the British Engineers' Association, 32 Victoria Street, London, S.W.1. (Tel. ABBey 2141); or to the Permanent Secretariat, International Mechanical Engineering Congress, 11 Avenue Hoche, Paris 8e.

COIL SPRINGS

***Coil Spring Federation Research Organisation, Annual Conference.**—Thurs., 5 June, to Sun., 8 June, at the Imperial Hotel, Torquay. Apply to the Federation, P.O. Box 121, 301 Glossop Road, Sheffield, 10. Tel. Sheffield 63031.

***Interferometry, Symposium on.**—Mon., 9 June, to Wed., 11 June, at Teddington. Organised by the National Physical Laboratory, Teddington, Middlesex. Tel. Molesey 1380.

Materials Handling Exposition, Eighth National.—Mon., 9 June, to Thurs., 12 June, at the Public Auditorium, Cleveland. Organised by Clapp and Poliak, Inc., 341 Madison Avenue, New York 17, U.S.A.

***Study and Documentation Respecting Water: International Meetings.**—Mon., 9 June, to Sat., 14 June, at Brussels and Liége, Belgium. Organised by C.E.B.E.D.E.A.U., 2 Rue A. Stevart, Liége, Belgium.

***Standardisation, 1958 Assembly of the International Organisation for.**—Mon., 9 June, to Sat., 21 June, at Harrogate. Organised by the British Standards Institution, 2 Park Street, London, W.1. Tel. Mayfair 9000.

Building Plant Exhibition, 12th.—Wed., 11 June, to Wed., 18 June, at Pebble Mill-road, Edgbaston, Birmingham. Organised under the auspices of the Ministry of Works, Lambeth Bridge House, London, S.E.1. Tel. RELiance 7611, ext. 1177.

Chemical and Petroleum Engineering Exhibition.—Wed., 18 June, to Sat., 28 June, at Olympia, W.14. Sponsored by the British Chemical Plant Manufacturers Association and the Council of British Manufacturers of Petroleum Equipment. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar Square, London, W.C.2. Tel. WHItehall 0568.

***High Energy Nuclear Physics, Second C.E.R.N. Conference.**—Mon., 30 June, to Sat., 5 July, at Geneva. Organised by the European Organisation for Nuclear Research (C.E.R.N.), Geneva 23, Switzerland.

British Fair of Industry and Commerce.—Fri., 4 July, to Sat., 19 July, at Belle Vue, Manchester. Apply to the exhibition manager, British Fair of Industry and Commerce, Belle Vue (Manchester), Ltd., Belle Vue, Manchester, 12.

Laundry, Dry Cleaning and Allied Trades Exhibition.—Thurs., 17 July, to Sat., 26 July, at Olympia, London, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar Square, London, W.C.2. Tel. WHItehall 0568.

***Micro 58: Exhibition of Photomicrographs.**—Wed., 23 July, to Wed., 30 July, at the Polytechnic, Regent Street, London, W.1. Organised by the Royal Microscopical Society, Tavistock House South, London, W.C.1. Tel. EUSton 2086.

***Training Student Engineers: Congrès International d'Etudiants Ingénieurs.**—Sun., 3 Aug., to Sat., 9 Aug., at Brussels. Organised by the Fédération Belge des Etudiants Ingénieurs (F.B.E.I.), Brussels.

***Western Electronic Show and Convention.**—Tues., 19 Aug., to Fri., 22 Aug., at the Pan Pacific Auditorium, Los Angeles. Organised by Wescon, 342 North La Brea Avenue, Los Angeles, Cal., U.S.A. Apply to Export Publicity and Fairs Branch, Board of Trade, Lacon House, Theobald's Road, London, W.C.1. Tel. CHAncery 4411. (Additional information.)

British Food Fair.—Thurs., 28 Aug., to Thurs., 11 Sept., at Olympia, London, W.14. Organised by the Food Manufacturers' Federation, Inc., 10 Mount Row, London, W.1. Tel. LEGation 2933.

Analogy Computation Meeting, Second International.—Mon., 1 Sept., to Tues., 9 Sept., at Strasbourg, France. Apply to Mr. F. H. Raymond, Association Internationale pour le Calcul Analogique, 138 Boulevard de Verdun, Courbevoire, Seine, France.

Domestic Equipment Trades Fair.—Tues., 2 Sept., to Thurs., 11 Sept., at Olympia, London, W.14. Organised by B. C. and D. Trade Exhibitions Ltd., 194-200 Bishopsgate, London, E.C.2. Tel. AVEnue 1444.

Handicrafts and Do It Yourself Exhibition, Sixth International.—Thurs., 4 Sept., to Fri., 19 Sept., at Olympia, London, W.14. Exhibition offices: 24 Store Street, London, W.C.1. Tel. MUSeum 9792.

WORLD POWER

World Power Conference, Sectional Meeting.—Sun., 7 Sept., to Thurs., 11 Sept., at the Queen Elizabeth Hotel, Montreal. Apply to the secretary, British National Committee, World Power Conference, 201-202 Grand Buildings, Trafalgar Square, London, W.C.2. Tel. WHItehall 3966. *Note:* A Sectional Meeting of the conference will be held in Madrid in 1960; the Sixth Plenary Meeting in Australia in 1962; and a Sectional Meeting in Switzerland in 1964.

***Instrument Automation Conference and Exhibit, 13th Annual.**—Mon., 15 Sept., to Fri., 19 Sept., in the Convention Hall, Philadelphia. Organised by the Instrument Society of America, 3443 South Hill Street, Los Angeles 17, Cal., U.S.A. Apply to Export and Publicity Fairs Branch, Board of Trade, Lacon House, Theobald's Road, London, W.C.1. Tel. CHAncery 4411.

Business Efficiency Exhibition.—Mon., 22 Sept., to Sat., 27 Sept., at the City Hall, Manchester. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate Hill, London, E.C.4. Tel. CENtral 7771.

Industrial Fuel Efficiency Exhibition.—Wed., 24 Sept., to Fri., 3 Oct., at Olympia, London, W.14. Organised, in association with F. W. Bridges and Sons, Ltd., by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester 3. Tel. Deansgate 6363.

Scientific Unions, International Council of, Eighth General Assembly.—Thurs., 25 Sept., to Sun., 5 Oct., at Washington, D.C., U.S.A. Apply to Dr. A. Atwood, National Research Council, National Academy of Sciences, Washington, D.C., or to the International Council of Scientific Unions, 29 Tavistock Square, London, W.C.1.

Commercial Motor Transport Exhibition, International.—Fri., 26 Sept., to Sat., 4 Oct., at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

Electrochemical Society Inc., Conference.—Sun., 28 Sept., to Thurs., 2 Oct., at Ottawa. Offices of the Society: 216 West 102nd Street, New York 25.

Textile Machinery and Accessories Exhibition.—Wed., 15 Oct., to Sat., 25 Oct., at Belle Vue, Manchester. Organised by Textile Recorder Exhibitions Ltd., Old Colony House, South King Street, Manchester 2. Tel. Deansgate 6903.

Public Works and Municipal Services Congress and Exhibition.—Mon., 10 Nov., to Sat., 15 Nov., at Olympia, London, W.14. Organised by the Municipal Agency Ltd., 70 Victoria Street, London, S.W.1. Tel. VICtoria 9132.

Building Trades Exhibition.—Tues., 11 Nov., to Sat., 22 Nov., at the City Hall, Deansgate, Manchester. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester, 3. Tel. Deansgate 6363.

***Electronic Computer Exhibition: Associated Scientific Symposium.**—Mon., 24 Nov., to Thurs., 27 Nov., at Teddington. Organised by the National Physical Laboratory, Teddington, Middlesex. Tel. Molesey 1380.

Electronic Computer Symposium and Exhibition.—Fri., 28 Nov., to Thurs., 4 Dec., at Olympia, London, W.14. Apply to Radio Communication and Electronic Engineering Association, 11 Green Street, London, W.1. Tel. MAYfair 7874.

***Gas Separation Developments in Industrial Low Temperature, Conference.**—Wed., 26 Nov., in London. Organised by the Physical Society, 1 Lowther Gardens, London, S.W.7. Tel. KENsington 0048. (*Cancelled.*)

Design

LIGHTWEIGHT UNIFLOW DIESEL ENGINE

Two small lightweight diesel engines running on the uniflow principle, are now being made in this country, under licence, by Drayton Diesels Limited, West Drayton, Middlesex.

Known as the types 34 and 35, they are respectively rated at 8 and 9 b.h.p. at 2,000 rev/min on the 12-hour rating. Sectional views of the type 34 are shown in Fig. 1, and the engine itself in Fig. 2.

The difference between the two models is that the 34 has a bore and stroke of 78 mm and 82 mm respectively, while the figures for the 35 are 94 by 94 mm. Both models weigh 150 lb. The cam shaft is splined into, and forms an extension of the built-up crankshaft, the whole assembly being carried by three roller bearings. Caged, double track roller bearings take the big-end assembly. The cylinder body is made up of an aluminium alloy finned jacket, shrunk on to a cast-iron liner. A flat-top aluminium alloy piston is used, with one plated and three plain compression rings. Needle rollers are employed in the small end bearing.

The inlet air enters first the crankcase, where it is compressed by the down stroke of the piston. Towards the end of the stroke, ports are uncovered in the side of the cylinder which communicate with the crankcase, and the air charge then enters the cylinder tangentially. The angle of entry causes a considerable degree of swirl and the exhaust products, together with the excess scavenging air, escape through the single centrally placed exhaust valve in the

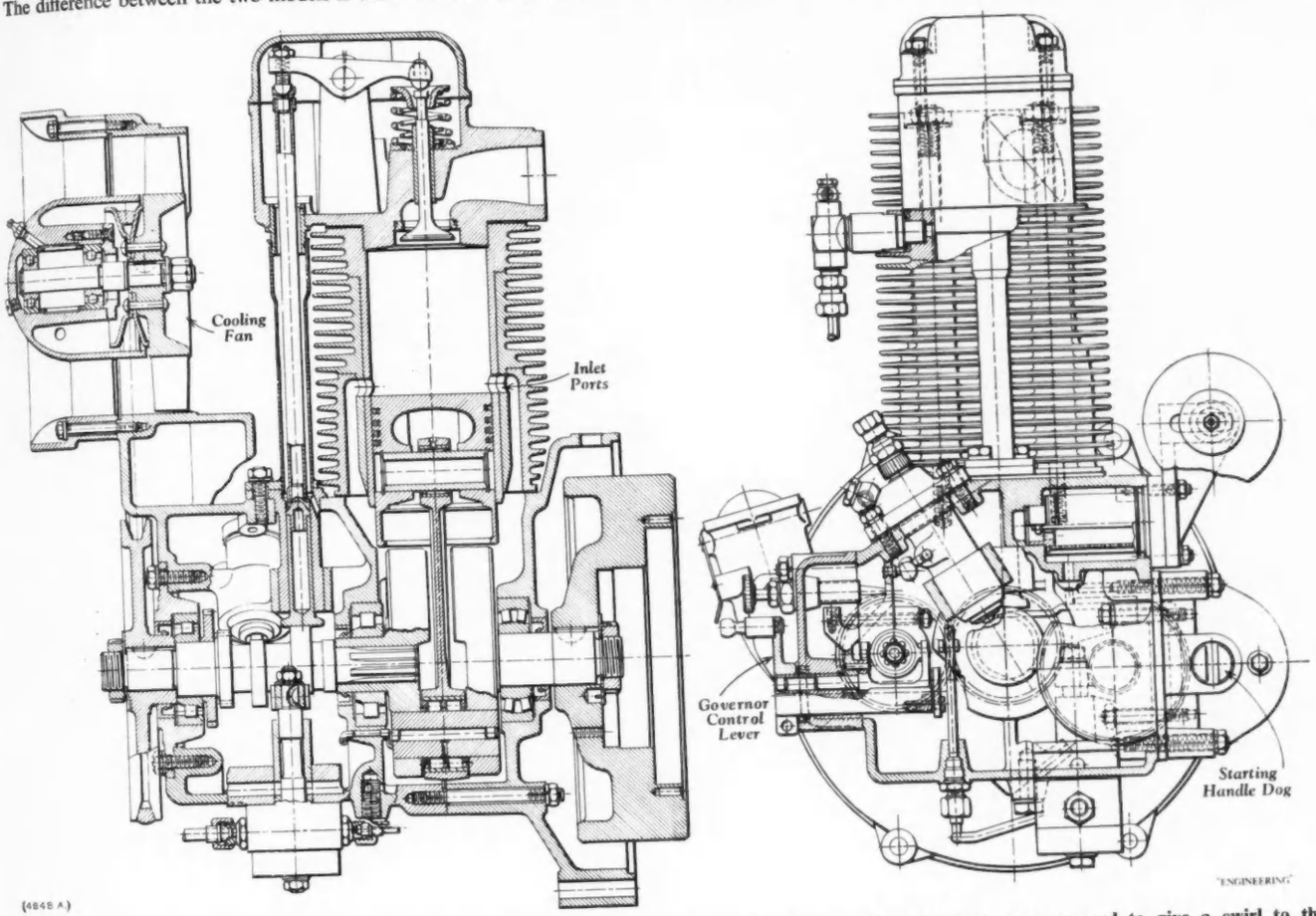


Fig. 1 The Drayton diesel engine utilises crankcase-compression for scavenging the cylinder. The inlet ports are arranged to give a swirl to the air charge, and the fuel spray is injected in the same direction.

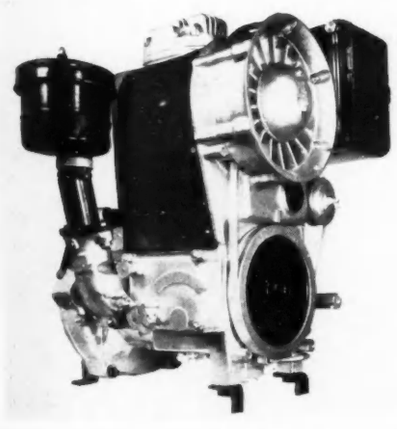


Fig. 2 The fan for supplying cooling air is mounted above the engine and blows into a casing surrounding the cylinder.

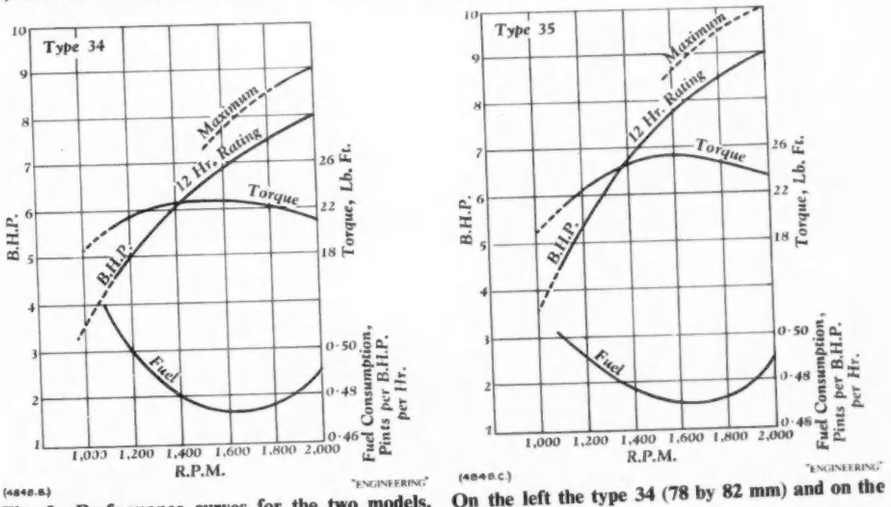


Fig. 3 Performance curves for the two models. On the left the type 34 (78 by 82 mm) and on the right the type 35 (94 by 94 mm).

Continuing Design

cylinder head. The injector is placed in the cylinder wall and is arranged so that the fuel enters with the same general tangential motion that the air charge already has. This is intended to give good mixing of fuel and air. A pintle type nozzle is used to produce the spray. Cooling of the cylinder is provided by an axial fan, driven from the crankshaft, which feeds into a cowling mounted around the cylinder.

The fuel pump and injector are either C.A.V. or Bosch types and the governor operates on the centrifugal principle. It is totally enclosed and can be arranged for variable or fixed speed governing as required. A circulatory oil system is employed for lubrication with a plunger pump supplying the various points. The oil tank is cast integrally with the casing, and the oil returned to it first passes through a filter. Any excess oil accumulating in the crankcase chamber is returned by the pump to the tank. The starting handle fits on a separate shaft which is linked to the combined crank and camshaft through gearing. An automatic de-compressing device is incorporated. Provision is also made for a starting cartridge or wick to be inserted in the cylinder head.

The performances of both engines are shown in the curves of Fig. 3. The maximum torque of type 34—22·8 lb ft—is developed at approximately 1,500 rev/min and the minimum fuel consumption is 0·474 pt per b.h.p.-hour at 1,600 rev/min. The engines are intended for general industrial, agricultural or marine use, and can be fitted with a clutch or a gearbox bolted on to the end-plate.

Rights for using the Drayton diesel engines in generating sets have been acquired by Dale Electric Limited, Filey, Yorkshire. To match the engines, the generators are also of lightweight construction so that a power/weight ratio of 135 lb per kW at 50 cycles has been achieved, with a maximum output of 3 kVA.

The Dexter range includes both electrically and manually started sets which can be supplied as stationary units, mounted in a frame for carrying, or on a two-wheel trailer. The generator is to B.S.2613:1955, is drip-proof, continuously rated at 3 kVA at 1,500 rev/min 50 c/s, and has an inherent regulation of $\pm$ 2½ per cent with unity power factor loads. As an example of dimensions, the hand-start portable model measures 42 in by 26 in by 26 in and weighs 420 lb complete.

INTEGRATING POWER AND HEAT

An integrated power and heating scheme has been constructed at the National Physical Laboratory, Teddington, using a G.E.C. back-pressure turbo-alternator set. The set normally runs in parallel with the mains, but can also be run as an independent unit so that the essential supplies to the laboratory can be maintained in the case of a power failure.

Steam is supplied to the turbine at 210 lb per sq. in and 540° F and is exhausted at 40 lb per sq. in, de-superheated and delivered to calorifiers for central heating purposes. To allow for varying conditions, a by-pass line with reducing valve and de-superheater is included. This can be brought into operation should the exhaust pressure drop by 1 lb per sq. in below its normal value. When the set is synchronised with the grid, a regulator valve maintains the back pressure constant and the electrical output varies according to the demand for heating. Alternatively, when the unit is running independently the turbine can be run under speed-governing conditions and the back pressure maintained by use of the reducing valve. The alternator is rated at 650 kW and is driven through David Brown reduction gears.

Book Reviews

THE OBITUARY OF THE BATTLESHIP

British Battleships. By OSCAR PARKES. *Seeley, Service and Company Limited, 196 Shaftesbury Avenue, London, W.C.2.* (120*s.* 6*d.*)

For many months now, H.M.S. Vanguard, the only British battleship capable of being readily made operational, has been lying in reserve awaiting her fate, which is almost certainly that of being sent before long to the shipbreakers; and within the past few weeks the last United States battleship in commission, the U.S.S. Wisconsin, has been taken out of service. The appearance of this book, the most comprehensive history of the development of the battleship yet attempted, is therefore timely; for the day of the battleship is now definitely over, and it is only a matter of a very few years before the last of the type goes to the scrapheap.

That the obituary of the battleship should be written by a medical practitioner is the clearest possibly testimony that there is still a role for the enthusiastic and knowledgeable amateur in a world that is increasingly tending towards specialisation; but the author of this book is no ordinary Doctor of Medicine. For the greater part of a long and active lifetime, which included service in the first World War as a Surgeon Lieutenant in the Royal Navy, in the Naval Intelligence Division, and subsequently as Director of the Naval Photographic Section of the Imperial War Museum, he has assiduously collected photographs of British and other warships; and for some years he was able to apply and extend his knowledge of them in the responsible offices of Editor of *Jane's Fighting Ships*, and, for a period, of the *Naval Annual*. He writes, therefore, with quite exceptional authority.

Though it is mainly devoted to the ironclad and its successor, the steel armourclad ship, the book starts, very properly, with the steam-driven wooden three-decker, and its dramatically sudden relegation to obsolescence, just 100 years ago, by the construction of the French ironclad Gloire. The British replied in 1860 with the Warrior and Black Prince—the former of which is illustrated wearing a Red Ensign, for it was not until 1864 that the Royal Navy ceased to distinguish Flag Officers as being "of the Red," "of the White" and "of the Blue."

It is only by comparing the illustrations of successive ships that it can be appreciated how gropingly empirical was the development of battleship design; sometimes affected by changes in propelling machinery, but much more often by the various stages in the long drawn out competition between gun and armour. For many years the process of evolution was hampered by the retention of sail power; Dr. Parkes' concise and highly informative chapters on the stages in that evolution bring out clearly the impetus given to the naval architecture of warships by the abolition of square rig, though the effect of that change was almost trivial by comparison with the influence of the steam turbine, the water-tube boiler, and the adoption of oil fuel.

Interspersed in the narrative are comparative studies of the progress in the other navies which had a bearing on British design policy; first, of course, the French Navy, then the German, and, finally, the influence of the United States through the Washington Treaty—which Germany and Japan promptly proceeded to ignore. Thus Dr. Parkes's work is in effect two books, one dealing with the development of the British battleships which form its ostensible subject, and the other a survey of the contemporary practice of other nations.

The amount of detail given about the careers of individual ships is truly remarkable, and in this respect alone the book is assured of a place as a standard work of reference. Of the 450 or so illustrations, the reproductions of photographs of ships—many of which are here published for the first time—are almost uniformly excellent. Some of the line diagrams are rather crude, and a number of them invite the reflection that much space might have been saved, without disadvantage, if they had been smaller—say, of the size adopted in the *Naval Annual*; but this is relatively a minor point. More unfortunate is the number of small errors, mainly in the spelling of ships' names, which have escaped detection; for example, Alexandria for Alexandra, which occurs several times. There are, however, commendably few mis-statements which are not immediately obvious—e.g., the assertion that the cruisers Birkenhead and Chester, of 1915, were built by "Armstrongs," whereas in fact they were constructed by Cammell Laird and Company at Birkenhead; and they are not likely to affect the assured reputation of the book as the most notable contribution to the history of the British steam Navy that has appeared for many years.

"THE GREAT EASTERN LAUNCHED US"

A Hundred Years of Engineering Craftsmanship. By RACHEL E. WATERHOUSE. Published privately by *Tangyes Limited, Cornwall Works, Smethwick, Birmingham.*

The great expansion of the engineering industry in the Nineteenth Century provided ample opportunity for an enterprising craftsman to start his own business. Such was the humble beginning of quite a number of large concerns which are to-day of international repute. Rather more rare, perhaps, but still to be found in manufacturing engineering, is the family business, under the control to-day of direct descendants of the founder. Against such a background, and in view of the fact that numerous business histories have been published, the history of Tangyes Limited, may appear to be of limited interest. Yet the reverse is the case. Dr. Waterhouse has gathered together, from the firm's own archives and elsewhere, a substantial amount of information, and has presented a well-balanced account of the business.

Industrial history has suffered from much mishandling in the past, not because the material was not available, but because writers forgot one elementary fact. It is what a firm made which is of supreme importance. Personalities count, but in the long run it is on the firm's products that its success or failure rests. Too many writers of industrial history, in their efforts to produce a readable, a dramatic, or even a romantic, story, have lost themselves and their readers in a maze of inconsequential gossip. Dr. Waterhouse has avoided this trap skilfully, and has with equal success steered clear of the opposite pitfall—ponderousness or pomposity; the story is very readable.

Simply because it has succeeded in doing what it set out to do, the book is to be commended. But that is not all. It is very well produced and illustrated, the reproductions of old catalogue engravings and an artist's impression of the works in 1884 are of particular value to students of engineering history.

Moreover, the story itself has some highlights which are not only of interest to-day but might well point a moral. The five Tangye brothers who founded the business were not all equally skilled engineering craftsmen, though they had one thing in common; they were not afraid of

work. George, for example, was rather the business man, whose skill and acumen in the rather tough world of Victorian trading served the firm in good stead for many years. He had a flair, too, for publicity, which was rare in the days when advertising, if used at all, was of a heavy and uninspired type. The infant firm of Tangye Brothers was put firmly on its feet by an order from Brunel for hydraulic jacks to help in the launching of the Great Eastern, and George Tangye saw the value of this connection with a celebrated event. He coined the phrase "We launched the Great Eastern, the Great Eastern launched us."

Joseph Tangye, on the other hand, was essentially an engineer, at his best in the works, and it was he, for instance, who recognised the value of the Cameron steam pump when it was offered to the firm by its inventor. Another of the brothers, James, also distinguished himself as an engineer; one of his achievements being the production of a horizontal steam engine which was designed for quantity production, and made extensive use of jigs and gauges. The engine was an immediate success, and continued to be made for many years.

Many other things were pioneered by the Tangyes. Shorter working hours, welfare schemes, industrial and technical education, all received the attention of the brothers, particularly Richard and George, who carried on the business after the other brothers had retired.

To-day, the business, though a public company, is still largely owned by the Tangye family, and is managed by direct descendants of the five brothers who came from the Cornish village of Illogan, and saw their opportunity in Birmingham in 1857. There is continuity, too, in the type of product. Many of the lines which were successful in the past, such as steam engines, have naturally been discontinued, while new products have taken their place, but hydraulic machinery, which first brought the firm to the notice of engineers, is still made. The founders would find the products of to-day very different from those of their own time, but they would appreciate the continuity. It is on this note that the book ends.

STAGES TO ORBIT

Project Satellite. Edited by KENNETH W. GATLAND. *Allan Wingate Limited, 12 Beauchamp Place, London, S.W.3.* (21*s.*)

It makes a refreshing change to review a book on rockets or satellites which is written by people who have really made a contribution to one of the most intricate and far-reaching developments in man's technical growth. Outstanding among their contemporaries are the books by Dornberger ("V-2") and Milton Rosen ("The Viking Rocket Story"), both worth-while accounts of the difficulties in rocket development rather than mere catalogues.

The present book has four sections, each written by authors who are active and well-known in fields of technology closely connected with rockets and satellites—and who are enthusiasts into the bargain. The first section, "From Small Beginnings . . .", is contributed by Wernher von Braun, who has, in a relatively short lifetime, seen the perfection of the A-4 rocket at Peenemunde, and then, through his intrinsic development at Redstone Arsenal in the United States on the Redstone and Jupiter vehicles, put the first American satellite into the sky with a Jupiter "C" vehicle. His section of the book is a good summary of the early days of German rockets and the building up of Peenemunde, and forms a useful adjunct to Dornberger's "V-2." Kenneth Gatland, a structural engineer on aircraft and guided weapons, has had satellite vehicles in mind for a long time: with colleagues in the British Interplanetary Society he was responsible in 1951 for the production of a practical design for a "Minimum Satellite Vehicle" which could be launched with a three-stage rocket, weighing 37,000 lb at take off. This design, through the Mouse project of Dr. S. F. Singer, may be considered as forming the basis of the design of the American Vanguard satellite. Gatland's section forms the major part of the book, and provides an historical survey of all the important proposals and projects for satellites which have been made since the war, when the practicability of such undertakings became manifest: it includes tabulated data on Gatland, Kunesch and Dixon's minimum satellite, Singer's Mouse, and Vanguard, and is sufficiently up-to-date to include data on Sputniks I and II. Much information is also given on high altitude sounding rockets, such as Viking I and II, which served not only their own purpose but gave valuable experience on satellite-launching problems.

H. E. Ross, an electronics engineer, provides the section dealing with the next step towards interplanetary flight, that of establishing orbital bases where men can live and work. Such bases have many uses in science and technology: an extra-terrestrial telescope, for example, would solve more problems in astronomy and cosmology than the biggest earth-bound telescope that could ever be built. The base could be used to assemble and prepare vehicles to travel to the other planets.

The book closes with a discussion of interplanetary flight by A. V. Cleaver, who, in his work at de Havillands and Rolls-Royce, has been responsible for the development of rocket power plants of many different types and sizes. He discusses the problems of designing vehicles and choosing suitable orbits for their travels, and makes a fitting close to the book when he considers the motivation which Man has for exploring space.

The book may be heartily recommended; it does not endeavour to talk down to its audience, but is never abstruse. As a primer on satellites, it is well worth the money.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Work Handling for Multi-Spindle Automatics. WICKMAN LTD., P.O. Box No. 44, Banner Lane, Coventry. Automatic loading of multi-spindle chucking automatics enables the full potential of the machine to be used. Seven different loading devices, ranging from a simple transfer arm type to a loading, reversing and unloading attachment, are described. Folder of duplicated sheets with photographic illustrations.

Hand-Held Power Tools. SELECTA POWER TOOLS LTD., Hampton Road West, Hanworth, Middlesex. Details of four power tools; a grinder using resin-bonded wheels, a ¼ in drill, a screw driver and nut runner, and a nibbler for sheet up to 16 s.w.g. All electrically driven. Four illustrated leaflets.

Heat Exchanger and Dryer. W. C. HOLMES & CO. LTD., Turnbridge, Huddersfield. "Holo-Flite" processor, heat exchanger and dryer. Material is moved along a trough by hollow screws through which the heat transfer agent is circulated. Models with single, double or quadruple screws. Publication PP 56/2.

Adjustable Clamping Blocks. INSLEY INDUSTRIAL SUPPLY CO. LTD., 21/22 Poland Street, London, W.1. Clamping blocks of hardened and tempered steel, to a tolerance of 0·004 in, with interlocking stepped profiles for height adjustment. Available in sets, covering different height ranges. Illustrated leaflet.

Ball Forming. FRANK WHITELEGG LTD., 304 High Street, Sutton, Surrey. Single blow press made by Th. Calow & Co., Bielefeld, Germany, for forming, from wire, balls up to 16 mm diameter. Illustrated leaflet.

On the Shelf

By Frank H. Smith

The National Council of Social Service, 26 Bedford Square, London, W.C.1, issues a series of *Citizens Advice Notes* for an initial charge of 4 guineas which covers the loose-leaf volume and all supplements for 12 months. Thereafter, the annual renewal fee is £2. Sample titles of leaflets cover such subjects as the regulations concerning State Scholarships, local planning regulations with regard to such things as the erection of transportable buildings, reinstatement after National Service, rating-assessment appeals, seating accommodation under the Factory Acts, and so forth. A great advantage of the service is its maintenance, whereby one is made aware of any changes in law.

I would suggest that anybody who wants an encyclopaedia at a bargain price should inquire at his booksellers regarding the new edition of *Dent's Everyman's Encyclopaedia*, the first two volumes of which will appear in April. Apart from the fact that its price is not in the satellite class it will fit into normal bookshelves.

The Institution of Production Engineers have produced a useful *Calendar of Events* of engineering institutions and professional bodies. It is interesting, looking down the typed foolscap pages, to see how the diary becomes more and more crowded as the year advances.

That monster volume, the forty-second *Annual Report of the National Advisory Committee for Aeronautics*, with Reports 1254-1295 covering 1956, has arrived. The 1,002 pages of it cost 7.50 dol. and it can be obtained through H.M. Stationery Office.

Spring approaches, and publishers' catalogues are, like Kipling's pilots, thicker than pilchards at Looe. Harrap's cover has a picture of H.M. the Queen descending a staircase (Palace Diary). Oxford University have a restrained woodland scene (Spring, 1958); Longman's show a clock—very Victorian, with an amorous shepherd gazing at his nude reclining love and the text "Omnia vincit amor;" Max Parrish show a cartoon with two gentlemen raising each other's hats. So it goes on, with the catalogues supplemented by leaflets and such monthlies as *The Bookseller*, *Technical Bookguide* and *Books of the Month*. Is it surprising that the librarian goes a trifle March hare at this time of year?

Those who were fortunate enough to attend the Aslib one-day conference on "Library Services in Technical Colleges," in October last will remember the sparkling talk by Lord Verulam on "Libraries: A Liberal Element in Technical Education." This address can now be obtained in reprint form from Aslib, 4 Palace Gate, London, W.8, price 3*s*.

My regular reader will know that one of the chips on my shoulder is the number of papers that are read in the course of a year and it is with glee, therefore, that I quote a headline from the American *Aviation Week* of 6 January—"Quality of Papers Sinks, Engineers Say." The word *is* sinks by the way. This opinion comes from a survey conducted by *Aviation Week* and if anyone would like to read it I will lend him the journal. Anything to further the cause.

The North Gloucestershire Industrial Education Council have issued the *Report on Conference on Modern Technological Education for Industry* which was held at the Town Hall, Cheltenham, in October last. On the 9th the subject was "The School Education for an Engineering Career" and on the 10th "The New Diploma in Technology" was discussed. It is evident that there is a great awareness of the need for education for industry in the West Country.

In June an International Congress on Vacuum Techniques (the first) will be held at Namur, Belgium. Interested inquirers should write to Professor E. Thomas, c/o CSN/ERM, 30 avenue de la Renaissance, Brussels 4.

Special Article

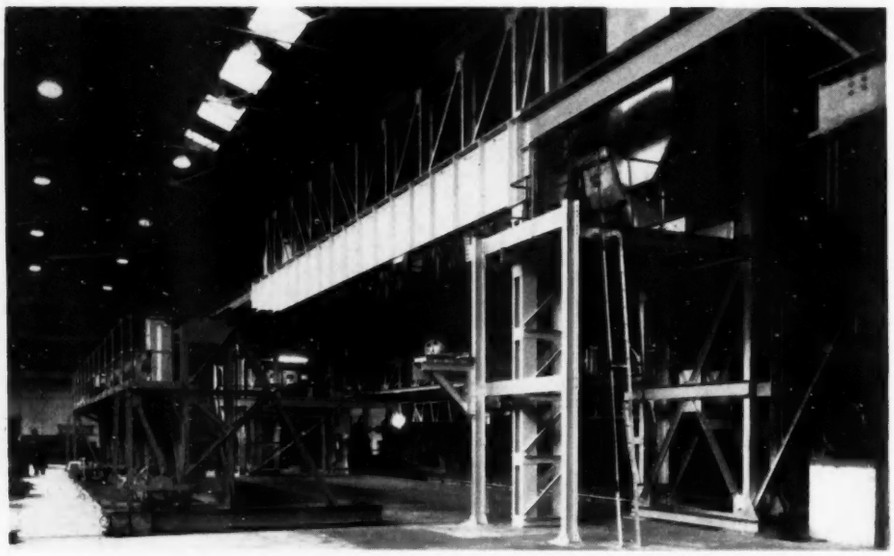
BIGGER AND BETTER ALUMINIUM PLATES

New designs and different production methods in many branches of engineering have brought about a need for larger and thicker plates in aluminium and its alloys, and the first part of a large development scheme undertaken by the Northern Aluminium Company, Limited, is aimed particularly at meeting these changed requirements. Other developments are planned; meanwhile, new plant installed at the company's works at Rogerstone, near Newport, Monmouthshire, enables plates to be supplied in widths and thicknesses hitherto unobtainable in this country.

Though they will have many different applications, the products of the Northern Aluminium Company's new plant at Rogerstone are of particular significance to two industries, aircraft manufacture and shipbuilding. Many large stressed components of aircraft, such as wing skins and tail surfaces, are now machined, complete with stiffening members, from thick plate, instead of being a riveted assembly of smaller parts. This technique calls for large plates of high-strength aluminium alloy, heat treated to develop the necessary mechanical properties, and with a low level of residual internal stresses, to ensure freedom from distortion after machining. It is important, too, that there shall be no small, undetected flaws in the material.

For shipbuilding, a factor limiting the application of aluminium plate has been the relatively small sizes available. Generally speaking, 7 ft was the maximum width of plate which could be offered. New rolling mill plant will provide the widths required, but as an interim measure, and as stated in our issue of 28 February, on page 281, Northern Aluminium are producing welded plates in widths up to 11 ft and lengths up to 30 ft. Noral B54S, for example, a 4½ per cent magnesium alloy, is welded with properties across the weld equal or very close to those called for in B.S.S.1477:NP5/6 for unwelded material, and it follows that for most purposes the weld can be ignored.

Large plates are now available trimmed to a high degree of accuracy and squareness, which will often eliminate the need for final trimming and edge preparation by the user. In addition, the highest standards of quality and freedom from flaws can be met. The new equipment just commissioned comprises a heat-treatment furnace, a large plate stretcher, a plate trimming saw, automatic welding equipment, and ultrasonic flaw detection apparatus, the complete plant being designed to handle plate up to 55 ft long, 10 ft wide and 6 in thick. Some of the equipment is capable of being enlarged to take even bigger plates in the future.



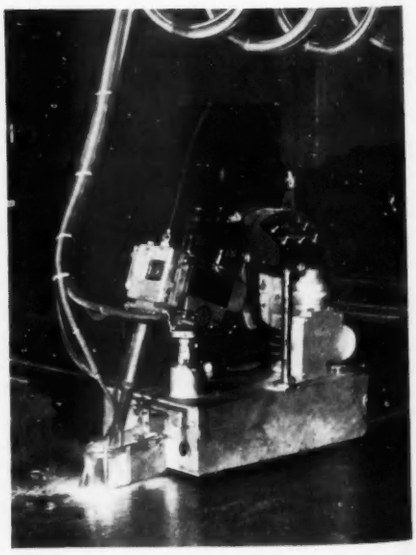
The heat-treatment furnace at Northern Aluminium is of the bottom loading type, with a quenching pit below. Charging is by means of a special carriage, seen on the left.

HEAT TREATMENT

Built by Stordy Engineering Limited, Wolverhampton, the heat-treatment furnace is designed for solution treatment and artificial ageing, as well as annealing. It will take as a single charge nearly 20 tons of plates for ageing at temperatures up to 200° C without quenching, 10 tons for solution treatment up to 550° C with a slow quench, and 5 tons for solution treatment up to 550° C with a high-speed quench.

The furnace is of the bottom loading type, with a quench tank immediately below the furnace chamber, and is electrically powered, with full air circulation, the heater batteries and

Stress relieving by stretching is done on this machine, which has a pull of 4,000 tons, and will take plates up to 50 ft long.

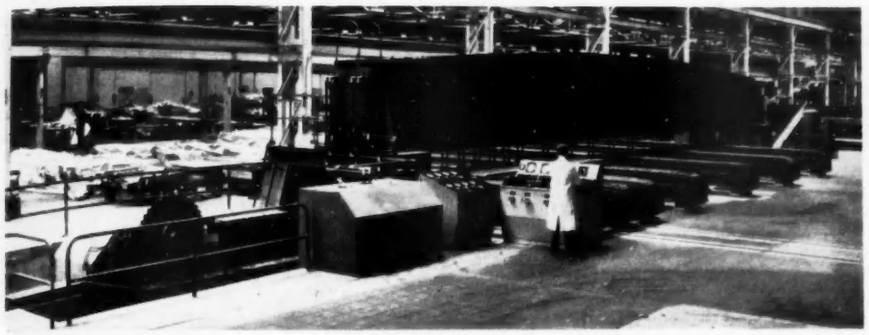


Large plates—up to 11 ft wide—are produced by Argonaut welding in a special plate holding jig.

fans being mounted at each end of the structure, outside the chamber. Each heater battery has three sections, of 166, 249 and 332 kW capacity respectively, giving a total loading of 1,494 kW. Independent switching provides fine temperature control. Four fans, each driven by a 40 h.p. motor, draw the circulating air through stainless steel ducts from the top of the furnace chamber, pass it through the heaters, and return it to the chamber.

No refractories are used in the construction of the furnace, which is lined with stainless steel, and carried on a riveted and bolted steel box girder, with a massive compound stanchion at each corner. Asbestos-sealed sliding joints in the furnace casing allow for expansion. The furnace door, also lined with stainless steel, consists of a number of 6 ft square sections, joined to form a continuous door, which is sealed when closed by asbestos cord, carried in heat-resisting castings round the door edge. A traversing carriage, running on rails 60 ft apart carries the door opening and closing apparatus, and serves to move the door, when it is opened, 8 ft along the rails to give clear access to the underside of the furnace chamber.

A concrete tank, 102 ft long, 10 ft 6 in wide and 15 ft deep, is located in the floor immediately below the furnace chamber, and a space 60 ft by 6 ft by 15 ft is available for quenching purposes; the rest of the tank is occupied by circulating pumps and passages. There are two axial flow circulating pumps, supplied by W. H. Allen, Sons and Company Limited, Bedford, and provision is made for altering the pitch of the impeller blades from floor level.



Plates are trimmed rapidly and accurately on a plate saw with hydraulic hold-down and conveyor feed and discharge.

STRETCHING

The Rogerstone stretcher, built by Loewy Engineering, Limited, Bournemouth, is basically of a type used for many years, but it is of large size, and has numerous new features, some of which are the subject of patent applications. The rated pull is 4,000 tons, and the machine will deal with a maximum cross-sectional plate area of 200 sq in; the maximum plate length, width and thickness it will accept are 50 ft, 10 ft and 6 in, respectively. Full provision is made in the design for the protection of the machine from shock damage should a plate break while it is being stretched.

There are two main compression members which, in side elevation, are level with the centre-line of stretch, and the machine is sunk in the floor to about this level. Mounted directly on the ends of the compression members are the two main hydraulic cylinders, which, by means of rams bearing on side extensions of the main grip head, move this head to apply the stretching load. The tail grip head is stationary during stretching, but to enable different lengths of plate to be accommodated, it is adjustable along the compression members, by means of nine anchor pin holes at 4 ft 6 in centres along the members, and hydraulically operated anchor pins in the head. Traversing of the head is by ram-operated tow bars sliding inside the compression members. In operation, tow-pins in the head engage with the tow bar while the head is moved through a 4 ft 6 in step, and then disengaged to allow the tow bar to return ready to make the next step.

The two main stretcher rams are 36½ in diameter and have a stroke of 7 ft 6 in. They are used for stretching only; for fast advance and return of the main head when not stretching there are double-acting rams 8 in. diameter, working in cylinders attached to the main ram cylinders by long tie bolts.

Plates for stretching are placed by the shop crane on a continuous disappearing apron attached to the adjustable head. Free-running rollers, on which the plate can be moved longitudinally, are built into the apron to facilitate manipulation of the plate into the gripping heads, and there are lifting and plate-centring devices provided on each head. Lengthwise positioning is by plate stops within the gripping jaws. The jaws in both heads are formed in ten segments, which do not have to be changed for different plate thicknesses. Each upper and lower pair of segments is mechanically centred, and all can move slightly relative to the others, to allow for some variation in plate thickness. Limited angular movement is provided for on the main head, so that it can take a plate which is slightly wavy along one edge. An initial "bite" to hold the plate is given by 400 ton hydraulic rams.

A general feature of the hydraulic system of the stretcher is the need, on the main advance and return tow bar and jaw-operating rams, for controlling two rams which are widely spaced and must travel at the same speed. Control is effected by operating the two rams from separate pumps and controlling the flow from each pump by bleed-off valves worked by a differential mechanical linkage.

There are three separate oil-hydraulic systems, one on each gripping head and one in the foundations supplying the main cylinders, the advance and return cylinders and the towbar rams. For the main hydraulic system there are two pumps, driven by a 150 h.p. double-ended, motor. Oil is delivered at 4,500 lb per sq in, and there is provision for increasing the pressure to 7,000 lb per sq in to give a 6,000 ton pull on the stretcher. A small pump supplies pilot pressure at 400 lb per sq in for the control valves. The hydraulic systems on the grip head supply the jaw cylinders and the plate lifting, centring and locating devices. On the adjustable head the system also provides power for the anchor and towbar pins. Two pumps are mounted on each head; one, driven by an 18 h.p. motor, delivers oil at 4,500 lb per sq in for the jaw cylinders, and, on the adjustable head, for the tow bar and anchor pin gear.

All the machine controls are grouped on panels, one on each head. On the main head panel, in addition to the push-button and pistol-grip controls, there is a stretch indicator, which shows the length of plate between the jaws, and the amount of elongation applied. The degree of stretch can be pre-set at 1, 1½, 2, 2½, 3, 4 or 5 per cent, and the machine will stop automatically when the set figure has been reached. As an alternative, provision is made for stretching to a pre-determined stress.

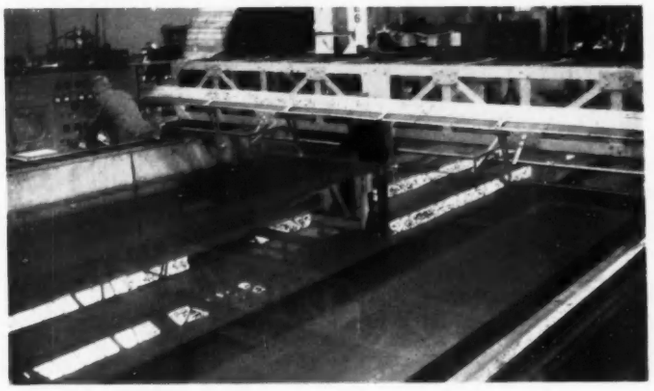
WELDING

Noral plate, in the non-heat-treatable alloys, can be butt welded in thickness up to 0·4 in lengths up to 30 ft and widths up to 11 ft by means of welding equipment developed by the company. The rig consists of a concrete base 35 ft long, carrying a welding jig on which the plates are held flat, and with the necessary gap between the edges. Welding is carried out by a British Oxygen Argonaut welding head, with a self-propelled carriage, the operating speed being generally between 15 and 150 in per min.

A single panel at one end of the machine houses the controls for the jig, the welding equipment, and for a plate turn-over mechanism which is brought into use after the weld has been made and the top weld bead removed by grinding. The plate is then turned over for removal of the under bead. Power for welding comes from a B.O.C. self-contained generator and rectifier set.

PLATE SIZING

Built to the same maximum size limits as the furnace and stretcher, the plate saw is capable of cutting plate 6 in thick in Noral 2S (commercially pure aluminium), or Noral 26S (a high-strength aircraft alloy containing copper), at 90 in a minute, with a saw peripheral speed of 10,000 ft a minute. Speeds and feeds in proportion are possible with other sizes, and plates of 3 in and below can be cut easily at 180 in a minute. Provision has been made in the design of the machine for future extension of its length to deal with plates 75 ft long.



Maintenance of quality is ensured by ultrasonic inspection. The equipment shown here can be operated either mechanically or manually.

The machine, built by Wadkin Limited, Leicester, has a circular saw driven by a 75 h.p. motor, and traversed by one of 6¼ h.p. Immediately above the saw is a box section fabricated steel beam, 68 ft long, on which there are 18 pairs of hydraulic jacks, arranged so as to hold down the plate being sawn. The jacks are not spaced evenly along the beam, but are grouped more closely at the control panel end, so that short lengths of plate can be cut without difficulty. For moving plate into position for trimming, and out again after the cut has been made, there are seven infeed and seven outfeed conveyors projecting at right angles to the saw

Continuing Production

traverse path, and on each side of it. Each of the conveyors, which were built by the Albert Mann Engineering Company Limited, Basildon, is 2 ft wide and 12 ft long, and is driven by a 1½ h.p. motor. Like the hold-down jacks, the conveyors are grouped more closely at the control end of the machine.

A straight-edge fitted along the line of the first pair of conveyors, at right angles to the line of saw cut, ensures an accurate square when end sawing. Swarf is disposed of by a drag-link conveyor extending beneath the saw path.

Control is from a desk at the end of the machine, and there is full interlocking to prevent operations from being started or stopped in the wrong sequence. The saw, which can be run out clear of the beam supports for maintenance purposes, has a tooth pitch of about 4 in., with a very deep gullet, and the teeth are tipped with tungsten carbide.

The ultrasonic test equipment is of American manufacture, having been designed and built by the Curtiss-Wright Company. It enables the plate to be examined in the fully-immersed condition, a method which ensures complete coverage of the plate, except for a thin " dead " zone comprising the top 0·1 in. of the material under test.

FLAW DETECTION

For examination the plate rests in a tank of water, 14 ft wide, 54 ft long and 3 ft deep. The probe unit, by which the ultrasonic wave is directed into the metal, is mounted on a carriage which runs on an aluminium scanner bridge, travelling, in turn, on rails at each side of the tank. It is thus possible for the probe unit to be traversed over the whole plan of the tank. The motors for driving the bridge, carriage and probe unit are mounted within the bridge, and a pinion at each end of the bridge, working in racks fixed on the tank, gives a positive drive. There are two adjustable stops which can be set at any required distance apart, and two fixed stops to prevent over-travel. Bridge and carriage motions may be automatic, or manually controlled by switches, and their speeds are infinitely variable from 5 to 90 ft a minute. It is possible to set the controls to give repeated automatic sweeps across the plate in steps as small as ⅛ in, or as large as 12 in.

The operator sits at a control panel remote from the tank, and can use either one of two ultrasonic systems, or both simultaneously. Of the two systems or " scans," the first supplies two-dimensional pip-type echo information at the first oscilloscope, telling the operator the depth at which the flaw has been found, and its size. Depth is shown by relating the position of the echo on the screen to the echoes received from the top and bottom plate surfaces, and the size is indicated by the amplitude of the trace. The second scan enables the operator to see a longitudinal or transverse section of the plate being inspected, the top and bottom surfaces being represented by bright horizontal lines on the screen, and defects showing up as bright spots. By correlating this information with the first scan, a complete picture of the fault and its position is obtained. To ensure that no flaw is overlooked, controls can be set so that scanning stops automatically when an echo signal is detected.

ASBESTOS TEXTILES AND BRAKE LININGS

To cope with the rapid expansion which has taken place in recent years in the production of asbestos textiles, belting and plastics materials, increasingly large areas of manufacturing space have been needed by Turner Brothers Asbestos Company Limited, Rochdale, Lancashire, a member firm of the Turner and Newall Limited organisation. The installation at Rochdale, which we understand constitutes the largest asbestos textile factory in the world, has been expanded practically to the limit of the site restrictions and to meet present and future needs a £4 million development project was launched by the company in 1947 on a site at Hindley Green, near Wigan, chosen on the recommendation of the Board of Trade.

The Hindley Green site occupies an area of some 140 acres and upon it two distinct factory blocks have been built. The first of these, the North Block, was completed in August, 1949, and is devoted to the manufacture of power-transmission and conveyor belting. It now employs 1,400 persons in the workshops and offices.

The foundations of the second or South Block were laid in January, 1954, and the buildings are now complete and have been occupied. Most of the workshops are in active production but, in a few, plant is still being installed. The South Block is devoted to the manufacture of various asbestos textiles, mainly brake-lining materials, a large proportion of which are supplied to Ferodo Limited, an associated Turner and Newall Limited company. Glass textiles and resinated asbestos moulding materials are also produced in this block.

The total floor area of the North and South Blocks is approximately 1 million sq. ft and the factory eventually will provide work for 1,900 persons in a neighbourhood which has suffered previously from periods of severe unemployment. The spaciousness of the new shops is well shown in Fig. 1, which depicts the weaving of asbestos brake-band linings on heavy looms in the South Block.

The goods produced in the North Block include rubber conveyor belting, as used in mass-production systems and quarries; fire-resistant anti-static P.V.C. conveyor belting, as supplied in large quantities to the National Coal Board, for coal transportation underground; flat rubber transmission belting of various types, including folded belting, square-edge belts and whip cord and endless belts; and V belts as used in all kinds of machine drives, including high-speed applications and those involving heavily-pulsating and shock loads.

The new South Block is relieving the manufacturing pressure on the company's Rochdale factory and will permit a greatly increased total production of asbestos textiles such as those used in the manufacture of fire curtains, protective clothing and in various types of fire-fighting equipment. Asbestos cloths are also used for heat insulation and as the basis of brake linings, while asbestos tapes constitute an important form of electrical insulation. The bulk of the asbestos-textile production of the South Block, however, will be devoted to brake-lining materials.

The South Block is also extending the company's facilities for the manufacture of glass-fibre materials, marketed under the trade name, Duraglas, the most important single use of which is as a plastics reinforcement. As our columns have shown from time to time, polyester resins reinforced with glass-fibre materials can be moulded into motor-car bodies, boat hulls, motor-cycle sidecars and other products, including components for the aircraft industry. Chemically and mechanically-bound non-woven glass-fabric mats, sold under the trade mark Duramat, have been developed specifically for the plastics industry. An experimental moulding in the form of a tray, made of glass-fibre reinforced plastics, using Duramat chopped-strand material, is shown being withdrawn from a press in Fig. 2. The glass yarns and rovings, which are the raw materials for these products, are manufactured by an associated company, Glass Fabrics Limited, Dungannon, Northern Ireland.

The third main group of products of the new South Block, namely, resinated asbestos thermo-setting moulding materials, has the trade name Durestos. This comprises a range of resinated asbestos felts, flocks and powders which are moulded into components for the textile, electrical, aircraft and other industries. Interesting applications are parts for guided missiles and aircraft drop tanks which latter, for several years, have been manufactured by Bristol Aircraft Limited from Durestos materials.

Fig. 1 (left) Weaving of asbestos brake-band linings on heavy looms at the new South Block in the Hindley Green factory, showing the spacious layout of the new shops.

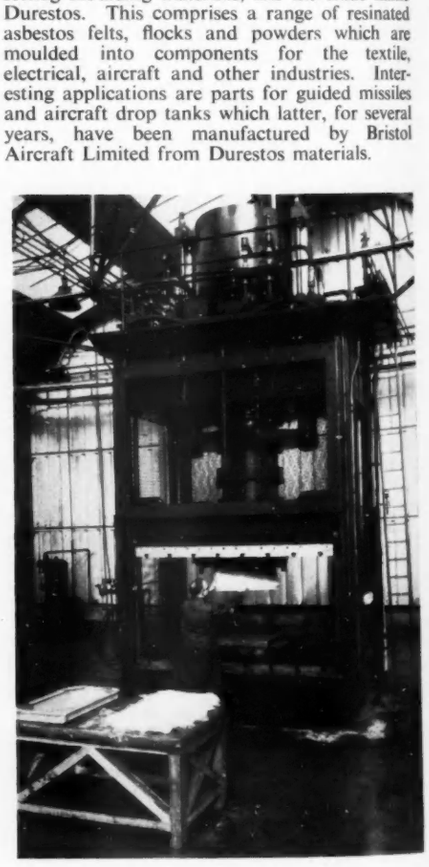
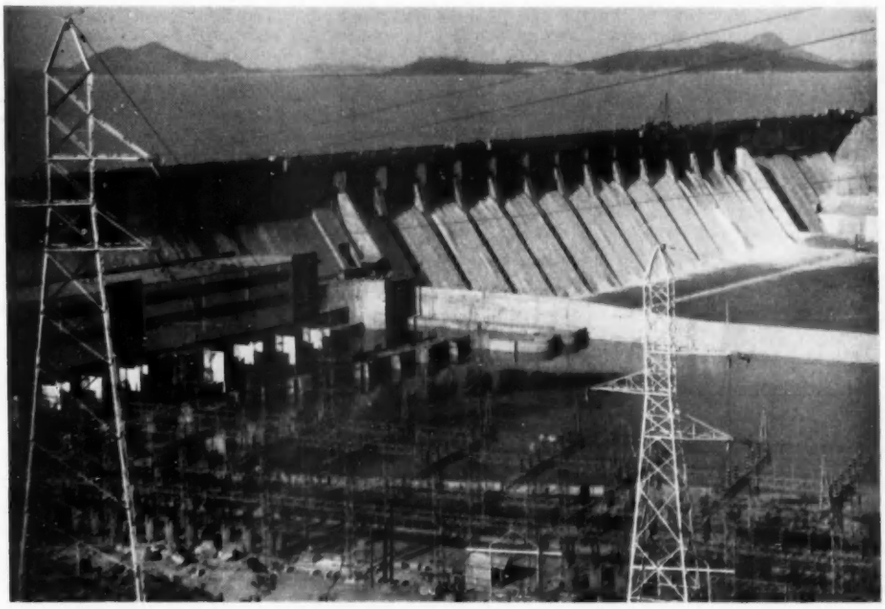


Fig. 2 (right) Experimental moulded tray of glass-fibre reinforced plastics, embodying non-woven chopped - strand glass fabric, being removed from the forming press.

Construction

THE LONGEST DAM IN THE WORLD

The Hirakud project in Orissa State, in India, is a multi-purpose undertaking for flood control, irrigation and power generation. The Hirakud dam is the largest concrete-masonry-earth dam in the world. The main structure is 15,745 ft long with a length of 3,768 ft in masonry and concrete, and the rest in earth. Its maximum height is 200 ft. It is flanked on either side by 13 mile long earthen dykes. The total number of labour employed on the project at peak periods exceeded 30,000 and the workers were drawn from all parts of India. The Hirakud reservoir extends over an area of 288 square miles, with a live storage of 4·72 million acre-ft. It has a shore line of 400 miles. Its storage capacity is double that of Tungabhadra and treble that of Mettur in South India. The Hirakud canal system will irrigate 454,000 acres of land by 1958-59. Facilities for canal irrigation have already been extended to 100,000 acres. The total installed capacity of hydro-electric power on completion of the first stage of the project will be 123 MW. There are rich mineral resources including iron, coal, manganese, bauxite, limestone and chromite in the Orissa State. The Hirakud project is the first major step in the exploitation of such mineral deposits. It will give a fillip to industries like cement, aluminium, steel, ferro-manganese, paper and textiles in this backward State.



The Hirakud dam and power station, with the switchyard in the foreground. The main dam, which is constructed in part of concrete, masonry and earth, has a total length of more than 3 miles. The project has the triple purpose of flood control, irrigation and power generation.

The plan for the development of the Mahanadi river in Orissa for providing and improving irrigation facilities, developing hydro-electric power and affording some protection from the recurring flood menace is the culmination of a succession of reports produced over the last 100 years or so. In 1945, the Central Waterways, Irrigation and Navigation Commission investigated the scheme for a reservoir across the Mahanadi that would not only serve the flood control purpose, but would also serve two other ends, namely, hydro-power generation, and better land use by irrigation. The Hirakud dam and reservoir was the first of the three reservoirs contemplated. In 1948 the foundation was laid for this dam, which was completed in 1956.

The concrete spillway under construction. With water up to the top reservoir level, the discharge is 600,000 cusecs. The reservoir has a live storage of 4·72 acre-ft.

The main dam is 3 miles long, thrown across four river channels between two hills; in addition, wide gaps have been closed in the hills on the flanks. On the left side of the main river there were five gaps in the hills totalling a length of 6 miles, and on the right a single one, 7 miles long. For this length of 16 miles, a concrete wall, or a dam " built-in-rocks " in mortar, was deemed inadvisable from an economic angle. Therefore, a dam made of loose materials—earth—was designed. The employment of large-scale earth moving machinery and a wide range of techniques for compacting alluvium to make an impervious barrier, all made possible by considerable theoretical and experimental research in this particular branch of soil mechanics in recent years, have helped to make the homogeneous dressed earth dam at Hirakud. The total quantity of compacted earth put in is 640 million cu. ft, out of which 440 million cu. ft have gone into the 3 mile main dam across the river channels between the two hills. Here it is a zoned section with an impervious earth core with semi-pervious zones up and downstream. About 60 per cent is impervious material, and 40 per cent semi-pervious. The foundation cut-off trench is placed at the upstream toe of the impervious section throughout. In one of the four river channels—the last to be blocked in 1954-55—an additional foundation cut-off trench has been placed centrally, and directly under the impervious embankment core, as a measure of additional precaution and safety against any subterranean flow. The bottom of the trenches was generally rocky throughout. Holes were drilled at intervals and cement grout injected to form an impermeable curtain to prevent underground flow. These drills were made about 30 ft deep, the intervals being determined by the degree of impermeability attained on either side of the hole. Closer spacing was adopted in certain locations.

The size of the earth dam was the factor that determined the employment of heavy mechanical equipment for dealing with earthwork and excavations. A mammoth fleet of earth digging, hauling, spreading and compacting equipment was used, much of it under an American-aid scheme. The selected earth from the borrow areas in the reservoir bed was hauled from a distance of some 3 to 4 miles and placed at site. Two-shift working was the practice. The production varied from 20,000 to 28,000 cu. yd of compacted earth on the main embankment each day. Daily field maintenance and regular weekly servicing, besides a special set up for attending promptly to heavy repairs in the field itself, helped to maintain the maximum working efficiency possible under the inevitable conditions of delayed supplies of essential spare parts.

The main barrier of earth across the valley was mechanically placed, with two spillways in a length of 2,125 ft for evacuation of floods. The spillway structure is pierced by 64 sluices, 20 ft by 12 ft, each placed at river-bed level. At maximum reservoir level these sluices are capable of discharging approximately 900,000 of cusecs. The spillway is surmounted by 34 radial gates, each 51 ft by 20 ft and capable of discharging another 600,000 of cusecs at maximum reservoir level. In the belly of this spillway structure is a gallery running for the full length with eight travelling cranes for operation of the sluice gates. It has been claimed that this long spillway, with all its operating galleries, battery of river bed sluices and crest gates, is the largest in the world.

The spillway is a concrete structure. The concrete was poured with the aid of two complete mechanical outfits, each comprising an aggregate crushing and conveying plant linked to a very generously dimensioned batching and mixing plant. The concrete was delivered into buckets of 2 and 3 cu. yd capacities and hauled by

Continuing Construction

locomotives to the site where cranes lifted them and poured the concrete into place. There were also available cement-handling plants. Some 750,000 cu. yd of concrete have gone into the spillways.

While the left end of the main dam was an earth section tied to the hill, the right end was a rubble stone masonry in cement mortar 928 ft long in which seven pipelines—five of 25 ft diameter and two of 23 ft diameter—have been embedded to draw water under a variable head to turn the power wheels and run the generating equipment located in a power house at the foot of the dam in rear. This part of the dam was originally designed as a concrete structure. Rubble stone in cement mortar was substituted to effect economy in cost and a saving in construction time. On account of this substitution the total cost has been less by several hundred thousand of rupees and the period of completion advanced by one year. This masonry is Deccan's traditional material built of mortar, tested and standardised for quality and efficiency. This "centuries old" masonry has been used in all masonry dams so far constructed, especially in South India, including that across the Tungabhadra river.

Some 550,000 cu. yd of rubble stone masonry in cement mortar have gone into the power dam and transitions. Where good granite or other building stone is available, stone masonry is definitely indicated in preference to a material made up of crushed stone bits of small sizes. Stone in cement mortar with the addition of some puzzalona of the type used on the Tungabhadra dam is superior to ordinary cement concrete from the point of view of flexibility and impermeability. This has been amply proved in the Tungabhadra dam where, even in the first year of filling, the drainage galleries above the foundations showed very much less than a normal leakage of a concrete structure. At Hirakud, India engineers have designed a simple testing station to test masonry cubes and it is being developed into a standard one which can be established anywhere in the country.

The power house built at the foot of the dam in rear is 628 ft long and 132 ft wide. In January, 1957, it housed four units—two of 37,500 kW each and two of 24,000 kW each. The draft tubes for two more units have been completed, and the generating units for these are being erected. There is a seventh bay reserved for installation of another unit in the distant future. Thus, there are several spare bays provided for peak load operations. With the reservoir power station functioning, the tail waters are taken through a separate canal for 16 miles and dropped again 75 ft into the river running close at hand. Three generating units of 24,000 kW each are being installed there. In these 16 miles the main river flows in rapids and falls about 80 ft in the reach. Advantage has been taken of this to install two more units of 37,500 kW each. The capital cost per kW at the reservoir power station works out to Rs. 3,000, which is high for hydro-power, but the subsidiary power station is much better off regarding installed price per kW at Rs. 1,700 because of the existence of the reservoir power station. This combination has enabled the power scheme to pay; the combined price per kW for the full project is Rs. 2,200.

The waters, after producing power at the dam and at the lower power station, travel 200 miles to the apex of the delta to irrigate land in Puri and Cuttack districts. There is enough steady water supplies all the twelve months in the year to enable cropping over 1,600,000 acres of land in the kharif and rabi seasons. There are also canal systems to the right and left of the dam that will irrigate an area of about 750,000 acres during both seasons in the Sambalpur and Bolangir-Patna districts. In all, a total of 436 miles of main canal and branches have been built, together with a further 2,015 miles of distributaries. The cost of this part of the project has worked out at Rs. 139 per acre.

The Hirakud project engineers also erected 230 miles of single-circuit and 84 miles of double-circuit of 132 kV as well as 30 miles of 66 kV transmission lines for delivering electricity *en route* and at places about 175 miles away for large industries. Close at hand is a 20,000 ton aluminium plant which takes 50 MW; a steel installation at Rourkela, a hundred miles away, taking 60 MW, and ferro-manganese unit at Joda, at a distance of 200 miles, which requires 20 MW. In addition, at the Cuttack end, and at intermediate points, are numerous industries like cement, paper, textiles and collieries. Finally, power is reserved for rural electrification, small-scale and cottage industries.

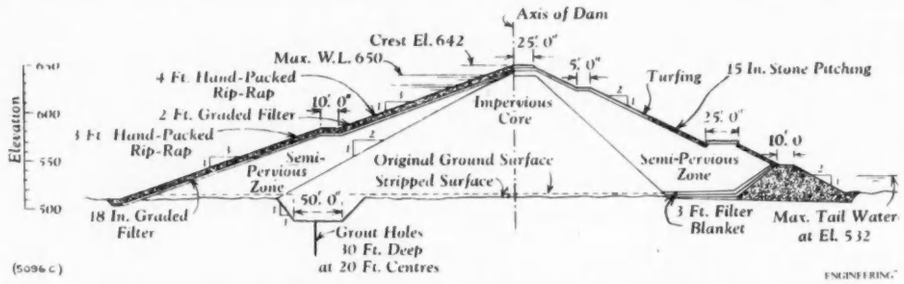
The Hirakud reservoir has a storage capacity of 6·60 million acre-ft of water. Out of this 1·88 million acre-ft is dead storage. The balance volume of the reservoir is there to fulfil the three purposes of irrigation, power production, and flood control. These objectives are overlapping, but by a judicious and planned regulation of the reservoir water levels, it is possible to achieve an appreciable benefit from the trinity. Indeed, during the 1956 monsoon the regulation of the reservoir outflow was so manipulated as to keep flood levels at Cuttack several feet lower than the normal peaks experienced in previous years.

This huge construction project, entailing techniques formerly considered a foreign expert's job, was executed by Indian engineers throughout. The chief engineer of the Hirakud project was Mr. Thirumale Iyengar, assisted by 24 executive engineers. Thus drilling, grouting, mechanised operations, erection, dismantling and re-erection of complicated plant employed in the mechanical operations were done by engineers, foremen, skilled and semi-skilled workers drawn from all parts of the country.

The Union Government executed the Hirakud project as agents for Orissa State, and they decided that the job should be carried out on a departmental basis under conditions then prevailing. They, moreover, felt that this would enable the Central Government to train a nucleus of indigenous personnel in such construction, and utilise the large quantities of surplus disposal stores and equipment.

The Tungabhadra workshops supplied the head gates for the Bargarh and Sason canals and Sambalpur distributary. Gates and other gate parts for the draft-tube outlets of the power house, shutters, for canal sluices and regulators, were fabricated at the Hirakud workshop itself. Four leading contracting firms furnished metal works like sluice gates, crest gates, penstock head gates, etc., and five electricity plants. Orders for the supply of plant and earth-moving machinery were placed with a great number of firms.

As a direct result of the Hirakud project, in less than a decade backward Orissa is expected to register substantial all-round economic progress, both in the agricultural and industrial fields.



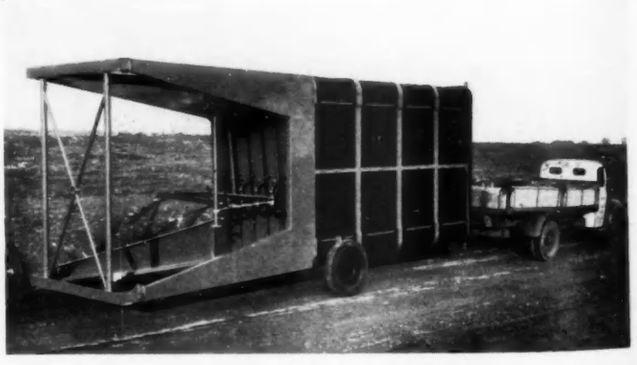
Profile of the earth dam at Hirakud. The main earth dam is 12,000 ft long and, in addition, six gaps (totalling 16 miles in length) have been closed by a similar structure.

MOBILE CEMENT SILO

Mobile cement silos, designed to cut transport and erection costs, are now being made and one is shown in the accompanying illustration. The use of silos, with the elimination of bagged cement, has grown rapidly during the last five years and relatively small silos have become a familiar sight on even small contracts. The addition of mobility will make their use even more attractive on either the smaller site or on the extensive site where the batching plant can be moved with advantage—on road construction for example.

The new silos are made of 15 mm plywood—to minimise the effects of condensation—mounted on a steel frame. Two models are available, the larger having a capacity of 40 tons of packed cement, the smaller 20 tons. The model in the illustration is the larger, which takes about 35 tons of aerated cement; as can be seen, it is hauled by a lorry without difficulty.

A 7·5 h.p. motor (electric or diesel) provides power for a built-in rotary blower. Only 5 h.p. is absorbed after starting up and the air supplied then gives complete aeration which ensures that the contents can be discharged cleanly. Incorporated in each silo is a weigh-beam scale which can be operated either automatically or manually to assist in accurate batching. The makers are Road Machines (Drayton) Limited, West Drayton, Middlesex.



Mobility makes this medium-size cement silo an attractive proposition —particularly for road construction.

NOTICES OF MEETINGS

British Institution of Radio Engineers

NEWCASTLE UPON TYNE
Annual General Meeting and Film Evening. North Eastern Section. Neville Hall, Westgate Road, Newcastle upon Tyne. Wed., April 9, 6 p.m.

British Interplanetary Society

LONDON
"Problems of Handling Large Missiles," by F. R. F. Taylor. Caxton Hall, off Victoria Street, S.W.1. Sat., April 5, 6 p.m.

Building Centre

LONDON
Films: "Forming of Metals," exhibited by Shell-Mex and B.P. Ltd. Wed., April 16, 12.45 p.m.

Combustion Engineering Association

LONDON
"Measurement of Oxygen in Flue Gases," by F. T. Ashmore; and "Measurement of Oxygen in Feed Water," by M. S. Timms, at 10 a.m. "Chemical Engineering in the Coal Industry," by Dr. G. I. Jenkins, at 2.30 p.m. Southern Region. St. Ermin's Hotel, Caxton Street, S.W.1. Thurs., April 10.

Helicopter Association of Great Britain

LONDON
"Powered Lift Systems," by Charles H. Zimmerman. Royal Aeronautical Society, 4 Hamilton Place, S.W.1. Fri., April 11, 6 p.m.

Illuminating Engineering Society

EDINBURGH
Annual General Meeting. Edinburgh Centre. Y.M.C.A., 14 South St. Andrew Street, Edinburgh. Wed., April 2, 6.15 p.m.
LEEDS
Annual General Meeting and Social Evening. Leeds Centre. Mansion Hotel, Roundhay Park, Leeds, 8. Fri., April 11, 7 p.m.
NOTTINGHAM
"Display and Small Store Lighting," by J. R. Just. Nottingham Centre. Offices of the East Midlands Electricity Board, Smithy Row, Nottingham. Thurs., April 10, 6 p.m.*

Incorporated Plant Engineers

LONDON
"A Small Generating Station and Its Relation to Process Steam Demands," by B. E. A. Vigers. London Branch. Royal Society of Arts, John Adam Street, Adelphi, W.C.2. Tues., April 1, 7 p.m.*
BRISTOL
"The Plant Engineer and Work Study," by H. A. Gomm. Western Branch. Grand Hotel, Bristol. Wed., April 9, 7.15 p.m.
DUNDEE
"Uses of Electronics," by R. B. Smith. Dundee Branch, Mathers Hotel, Dundee. Mon., April 7, 7.30 p.m.
EDINBURGH
"Development of Diesel Traction on British Railways," by V. Atkinson. Edinburgh Branch. 25 Charlotte Square, Edinburgh. Tues., April 1, 7 p.m.
LEEDS
Annual General Meeting. West and East Yorkshire Branch. The University, Leeds. Mon., Mar. 31, 7.30 p.m.
LEICESTER
Members' Problem Evening. Leicester Branch. Bell Hotel, Leicester. Wed., April 2, 7 p.m.
PETERBOROUGH
"Boiler House Management," by O. H. Barker. Peterborough Branch. White Lion Hotel, Church Street, Peterborough. Tues., April 1, 7.30 p.m.

Institute of Fuel

LONDON
"Lacq: Its Problems and Potentialities," by André Blanchard. Institution of Civil Engineers, Great George Street, S.W.1. Thurs., April 10, 5.30 p.m.*
MANCHESTER
Annual General Meeting at 2.15 p.m. "Britain's Fuel and Power Problems," by Engineer Rear-Admiral Sir Sydney Frew, at 2.30 p.m. North Western Section. Engineers' Club, Albert Square, Manchester. Wed., April 9.

Institute of Metals

LONDON
Annual General Meeting. "New Protective Coatings for Metals," by W. E. Ballard. London Local Section. Thurs., April 3, 6.30 p.m.*
OXFORD
Annual General Meeting and At Home. Oxford Local Section. Department of Metallurgy, Oxford University, University Museum, Park Road, Oxford. Tues., April 1, 7 p.m.

Institute of Petroleum

LONDON
"Electrostatics and Explosion Hazards in the Petroleum Industry," by Dr. A. Klinkenberg. Wed., April 2, 5.30 p.m.*

Institute of Refrigeration and Physical Society (Low Temperature Group)

LONDON
"An Experimental Study of the Use of Mixed Refrigerants for Obtaining Cooling Over a Temperature Range," by Dr. G. G. Haselden and Dr. L. Klimek. Junior Institution of Engineers, Pepys House, 14 Rochester Row, S.W.1. Tues., April 1, 5.30 p.m.*

Institute of Road Transport Engineers

BATH
Annual General Meeting. Western Centre. Angel Hotel, Westgate Street, Bath. Thurs., April 10, 7.15 p.m.*
BIRMINGHAM
Annual General Meeting. Midlands Centre. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2. Tues., April 8, 7.30 p.m.

Institution of Civil Engineers

LONDON
"Long Term Effects of Training Walls, Reclamation and Dredging on Estuaries," by Sir Claude Inglis and F. J. T. Kestner. Tues., April 1, 5.30 p.m.*
MANCHESTER
"Jodrell Bank Radio Telescope," by H. C. Husband. North Western Association. Engineers' Club, Albert Square, Manchester. Thurs., April 10, 6.30 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Economic Aspects of Electrical Engineering," opened by D. J. Bolton. Education Discussion Circle. Tues., April 1, 6 p.m.*
Informal Evening on "Ultra-High-Frequency Test Transmissions." Radio and Telecommunication Section. Wed., April 9, 5.30 p.m.*
"Radio Observations on Artificial Satellites," by J. A. Ratcliffe. Thurs., April 10, 5.30 p.m.*
EDINBURGH
"D.G. Winder Drives Using Mercury-Arc Rectifier/Inverters," by L. Abram, J. P. McBreen and J. Sherlock. South East Scotland Sub-centre. Carlton Hotel, North Bridge, Edinburgh. Tues., April 1, 7 p.m.
GLASGOW
"Ship Stabilisation," by J. Bell. South West Scotland Sub-centre. 39 Elmbank Crescent, Glasgow, C.2. Wed., April 2, 7 p.m.
HULL
"Static Electricity in Industry," by G. Moore. North Midland Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Thurs., April 3, 6.30 p.m.
LIVERPOOL
Annual General Meeting. "Colour Television," by L. C. Jesty and Dr. E. L. C. White. Mersey and North Wales Centre. Royal Institution, Colquitt Street, Liverpool. Mon., Mar. 31, 6.30 p.m.
MANCHESTER
"Generation of Electricity in the London Area," by H. V. Pugh. North Western Centre. Engineers' Club, Albert Square, Manchester. Tues., April 1, 6.15 p.m.
YORK
"Control and Instrumentation of a Nuclear Reactor," by A. B. Gillespie. North Midland Centre. Royal Station Hotel, York. Tues., April 1, 7 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Provision of Ore-Handling Facilities at General Terminus Quay, Glasgow," by A. Young and G. Gray. Tues., April 1, 6.30 p.m.

Institution of Heating and Ventilating Engineers

LEICESTER
Annual General Meeting and Social Evening. East Midland Branch. Grand Hotel, Leicester. Wed., April 2, 6.30 p.m.
LIVERPOOL
Annual General Meeting. Liverpool Branch. College of Building, Clarence Street, Liverpool. Wed., April 2, 6.30 p.m.

Institution of Highway Engineers

NORWICH
Annual General Meeting and Film Evening. East Anglia Branch. Assembly House, Norwich. Tues., April 1, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
1958 Leonardo da Vinci Grammar and Public Schools Lecture on "Rockets and Guided Flight," by A. D. Baxter, L. H. Bedford and G. W. H. Gardner. Tues., April 1, 10 a.m. and 2.45 p.m. (By invitation.)
Discussion on "Problems Arising from Steam Conditions in Nuclear Power Stations, with Special Reference to Turbine, Boiler and Auxiliary Plant Design and to Nuclear-Fossil Fuel Cycles." Steam Group. Wed., April 9, 6 p.m.*
BELFAST
Thomas Hawksley Lecture on "Some Engineering Problems in Connection with the Industrial Application of Nuclear Energy," by Sir Claude Gibb. Northern Ireland Branch. Belfast College of Technology, Belfast. Tues., April 1, 7.30 p.m.

Institution of Production Engineers

BELFAST
"Work Study," by A. J. Speakman. Northern Ireland Section. Kensington Hotel, Belfast. Thurs., April 10, 7.30 p.m.
CHATHAM
Annual General Meeting at 7 p.m. Film Display at 7.30 p.m. Rochester Section. Prince of Wales Hotel, Chatham. Thurs., April 10.
MANCHESTER
"Ceramic Cutting Tools," by G. R. Connor. Manchester Section. Manchester College of Science and Technology, Sackville Street, Manchester. Mon., Mar. 31, 7.15 p.m.
NEWCASTLE UPON TYNE
Annual General Meeting and Tour of the College. Newcastle upon Tyne Section. Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne. Mon., April 14, 7 p.m.

Institution of the Rubber Industry

LONDON
Annual General Meeting and Supper. London Section. Criterion, Piccadilly, W.1. Tues., April 8, 6.30 p.m.
MANCHESTER
Annual General Meeting and Social Evening. Manchester Section. Engineers' Club, Albert Square, Manchester. Mon., April 14, 6.45 p.m.
MELKSHAM
Annual General Meeting and Film Evening. West of England Section. Melksham House, Melksham. Wed., April 2, 7.30 p.m.

Junior Institution of Engineers

LONDON
"Industrial Applications in Connection with Television," by T. M. C. Lance. Fri., April 11, 7 p.m.*

Newcomen Society

LONDON
"Essex Windmills," by Rex Wailes. Wed., April 9, 5.30 p.m.

Non-Destructive Testing Society of Great Britain

BIRMINGHAM
"Gamma Radiography," by G. H. Sanders. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Sat., April 12, 10.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE UPON TYNE
"Water-Lubricated Bearings in Marine Use," by A. D. Newman. Neville Hall, Westgate Road, Newcastle upon Tyne. Mon., Mar. 31, 6.15 p.m.*

Reinforced Concrete Association

LONDON
"Code of Practice for the Use of Normal Reinforced Concrete in Buildings," by H. G. Cousins. Institution of Structural Engineers, 11 Upper Belgrave Street, S.W.1. Wed., April 2, 6 p.m.*
BIRMINGHAM
"A Style of Building in Precast Reinforced Concrete," by T. W. Beecham. Midland Counties Branch. Birmingham and Midland Institute, Paradise Street, Birmingham. Tues., April 1, 6 p.m.*

Royal Aeronautical Society

LONDON
"Guided Weapons," by Dr. R. Cockburn. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Thurs., April 10, 6 p.m.*

Royal Meteorological Society

LONDON
Symons Memorial Lecture on "Solar Radiation," by Professor C. W. Allen. Wed., April 2, 5 p.m.*

Société des Ingénieurs Civils de France (British Section)

LONDON
"Lacq: Its Problems and Potentialities," by André Blanchard. Institution of Civil Engineers, Great George Street, S.W.1. Thurs., April 10, 5.30 p.m.*

Society of Chemical Industry

LONDON
Annual General Meeting and Spring Lecture on "Corrosion Research and Its Industrial Background," by W. H. J. Vernon. Corrosion Group. Wed., April 16, 6.30 p.m.

Society of Engineers

LONDON
"Soil in British Railway Civil Engineering," by A. H. Toms. Junior Institution of Engineers, Pepys House, 14 Rochester Row, S.W.1. Mon., Mar. 31, 5.30 p.m.*

Society of Instrument Technology

LONDON
Annual General Meeting. "Electronically-Operated Power Plant Instrumentation and Control," by R. E. J. Putman. Control Section. Manson House, Portland Place, W.1. Wed., April 16, 7 p.m.*
BIRMINGHAM
Annual General Meeting. Presidential Address by Sir Harold Hartley, G.C.V.O. Midland Section. Regent House, St. Phillips Place, Colmore Row, Birmingham, 3. Fri., April 11, 7 p.m.
FAWLEY
Annual General Meeting and Film Evening. Fawley Section. Copthorne House, Fawley, Hants. Fri., April 4, 7 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
Symposium "From Furnace to Mould." Papers by T. McCulloch, T. Urie and R. McDonald. Fri., April 11, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough Gardens, London, S.W.1. (TATe Gallery 9371.)
Building Centre, 26 Store Street, London, W.C.1. (MUSeum 5400.)
Combustion Engineering Association, 6 Duke Street, St. James's, London, S.W.1. (WHItehall 5536.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, S.W.1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria Street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire Street, Portland Place, London, W.1. (LANgham 7124.)
Institute of Metals, 17 Belgrave Square, London, S.W.1. (BELgravia 3291.)
Institute of Petroleum, 61 New Cavendish Street, London, W.1. (LANgham 3583.)
Institute of Refrigeration, New Bridge Street House, New Bridge Street, London, E.C.4. (CENtral 4694.)
Institute of Road Transport Engineers, 69 Victoria Street, London, S.W.1. (ABBey 6248.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria Street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield Street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W.8. (BAYswater 9101.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1. (VICtoria 0786.)
Newcomen Society, Science Museum, Exhibition Road, London, S.W.7. (KENsington 1793.)
Non-Destructive Testing Society of Great Britain, 2 Tomswood Terrace, Barkingside, Essex. (HAInault 5488.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne, 1. (Newcastle 20289.)
Physical Society, 1 Lowther Gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton Place, London, W.1. (GROsvenor 3515.)
Royal Meteorological Society, 49 Cromwell Road, South Kensington, London, S.W.7. (KENsington 0730.)
Société des Ingénieurs Civils de France (British Section), 82 Victoria Street, London, S.W.1. (VICtoria 6838.)
Society of Chemical Industry, 14 Belgrave Square, London, S.W.1. (BELgravia 3681.)
Society of Engineers, 17 Victoria Street, London, S.W.1. (ABBey 7244.)
Society of Instrument Technology, 20 Queen Anne Street, London, W.1. (LANgham 4251.)
West of Scotland Iron and Steel Institute, 39 Elmbank Crescent, Glasgow, C.2. (Central 5181.)

Engineering at Home

TIMBER, FIBRE, AND FOIL

A timber frame bungalow that can be transported on lorries and erected where required is produced by Stephenson Developments (Huddersfield) Limited. It is estimated that the three-bedroom version, with a floor area of 910 sq. ft, can be erected anywhere in the United Kingdom for less than £2,500. Plans are also being made to export the " New Trend " houses, as they are called, to Commonwealth countries and the Middle East. Timber is the basic structural material but stone, brick, glass and the newer synthetics are used as well.

The company supply, and in certain cases erect, the dwellings on prepared foundations. Drainage and site works are carried out by the local contractor. His work includes preparing foundations, which consist of longitudinal sleeper walls in concrete blocks, or brickwork, for the floor sections to rest on, and erecting the traditional walling that makes up the outer leaf of the gable walls. All floors are prefabricated in 6 ft wide sections; they are finished in tongued and grooved softwood boarding with glass fibre insulation. A hardwood floor is provided in the lounge and P.V.C. tiles are fitted to the kitchen and bathroom areas.

The exterior walls are of 4 in by 2 in framing, of Douglas fir or hemlock, with glass fibre insulation and inner lining of $\frac{1}{2}$ in plasterboard with aluminium foil backing. The side walls have an exterior cladding of 1 in vertical secret-nailed moulded African mahogany. The gable walls have an exterior cladding of $\frac{1}{4}$ in phenolic-bonded Douglas fir plywood treated with rubber based paint on the cavity side to receive the outer skin of traditional stone or brickwork. The interior partitions are of similar frame construction with glass fibre insulation and $\frac{1}{2}$ in foil-backed plasterboard, or veneered in walnut or figured oak faced plywood.

Solid 11 in by 3 in Douglas fir roof trusses are used. They are at 6 ft centres and cambered to the front of the bungalow. The lounge trusses are designed to be left exposed, giving a nominal room height of 9 ft. But the trusses can be underdrawn to give a flush ceiling 8ft high. The roof decking is made up of 6 ft wide boarded roof sections on purlins at 2 ft centres. Glass fibre insulation is used and the roof finish is to B.S. 747, consisting of 3-ply asbestos-based roofing felt with a one-ply centre layer and a green mineral surfaced top layer, all laid in hot bitumen. The gutters are built in behind the facias, which are of 9 in yellow pine.

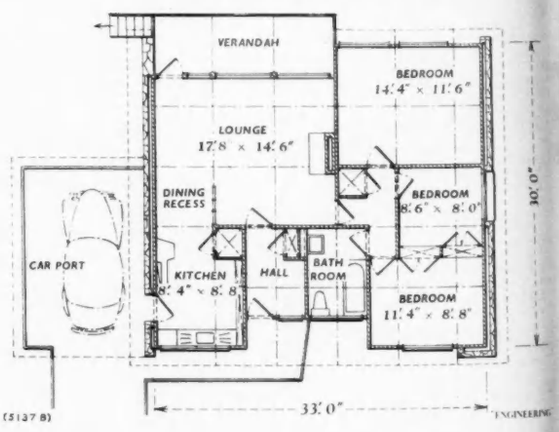
The 4, 3, and 2 bedroom bungalows have a car port included in the basic price. A car port is an open-fronted garage. In the New Trend buildings it has wired, obscured glass walls and is designed as a multi-purpose area, for use as a play space, conservatory, fuel store, and dustbin recess, as well as for car storage.

A prototype house, to the design of Mr. P. W. Watkinson, A.R.I.B.A., was recently completed at Almondbury, Huddersfield. In it there are over two standards of surfaced Pacific Coast hemlock spruce. The combination of aluminium foil and glass fibre insulation provides very low thermal transmittance. In fact a U value of 0·156 is achieved, compared with 0·31 for a 11 in brick cavity construction. A quantitative account of the value of reflective materials and fibrous materials for insulation in buildings is given in *Building Materials and Structures Report* 151, published by the National Bureau of Standards, Washington, D.C. (Mentioned in more detail on this page on 24 January, 1958.) The good insulation, say the firm, makes the use of small wattage electric convectors an economic form of bedroom heating.

The houses are designed so that oil-fired warm air heating can be simply installed to serve all the rooms. A degree of air conditioning in the summer can be achieved by circulating cold air with the fans. Electric underfloor panel heating can be installed as an alternative. This system has half the installation cost and has the advantage that individual rooms can be switched off and the load reduced; the running costs would be higher though.

The electrical installation conforms to I.E.E. and local electricity board requirements. However, the number of outlets in the basic layout is surprisingly inadequate. The working kitchen, for example, has one light point, one ironing plug and one plug for a cooker. This can be compared with the 5 socket outlets and 5 lighting points recommended by Mr. E. J. Davies in his paper to the 1957 British Electrical Power Convention, " The Economics of the Well Wired Home." Such a small basic provision invites the use of adaptors and long trailing flexes, introducing risks of fire and shock.

All wallpapering is included in the basic price. " Rydura " washable fabric wall papers are used in both the kitchen and the bathroom areas. Windows are of selected redwood with B.M.A. window fittings and 32 oz glazing in rubber U channel. Picture windows have hardwood mullions. Double glazing is offered as an optional extra to either the large picture windows or to all the windows. Ventilated glazed rectangular dome type roof lights are provided to the bathroom. The plumbing installation uses all copper pipework and Yorkshire copper fittings.



The Douglas fir roof trusses of the monopitch roof are left exposed in the lounge. The car port is designed as a multi-purpose area and has wired, obscured glass walls.

ELECTRICITY AT THE PAVEMENT

To save the time of meter readers, the Thurrock district of the Eastern Electricity Board installed meters in the outside walls of five new houses in West Thurrock. The instruments are housed in stout metal boxes and the door, which is fastened securely, can be opened by a key to allow access to the sealed fuses. The dial panel is visible through a sheet of reinforced glass. Mr. J. Unwin, the district manager, is reported in the March issue of *Electricity* as saying that as much as 30 per cent of his meter readers' time is wasted by calls on houses that are unoccupied at the time. If the new experiment is successful it should reduce wastage considerably. The meters are not suitable for prepayment consumers because their fitment would entail a walk into the street every time a shilling had to be put into the meter.

In the same issue it is reported that an experimental electrical pavement heating installation at a shopping centre in the new Llanrumney housing estate, Cardiff, was successfully tried out during recent snowfalls. The experimental area, which is about 480 sq. ft, remained free of snow during two moderately heavy falls. The installation is thermostatically controlled at 34° F. Over a four day period it consumed 202 kW.

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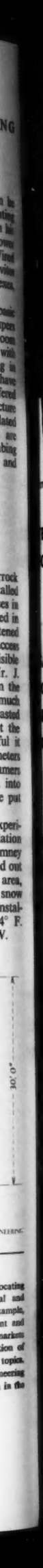
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